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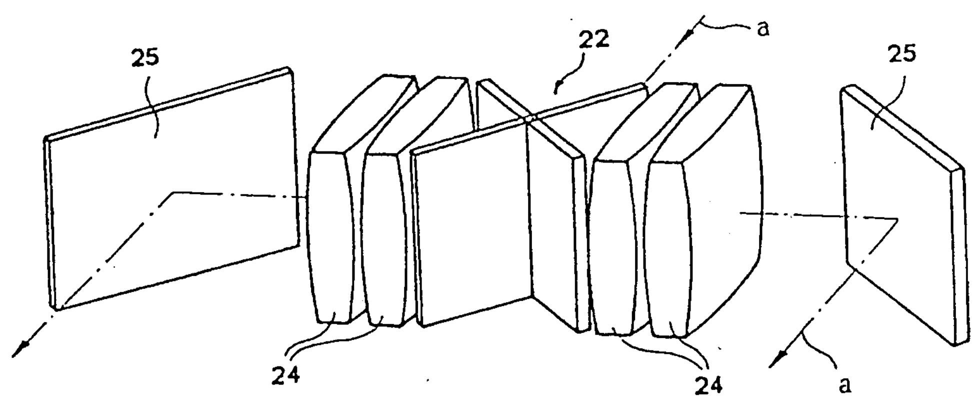
(54) Title: OPTICAL BEAM-SPLITTER UNIT AND BINOCULAR DISPLAY DEVICE CONTAINING SUCH A UNIT



(57) Abstract: The invention relates to an optical beam-splitter unit which contains crossed transparent planoparallel plates (6, 7), starting at a common intersection line (4) with light reflecting surfaces that diverge towards the light beam to be split. The binocular picture display device that is also subject of the invention contains an optical beam-splitter unit and it has first focusing elements (24) and mirrors in front of the eyes (25). This device is characterised by that its beam-splitter unit is the above described one, the first focusing elements (24) are placed at two opposite sides as seen from the direction of the beam arriving to the semitransparent reflective surfaces of the optical beam-splitter unit (22) i.e. from the receiving direction (5) and the common optical axis (23) of the first focusing elements (24) is at right angles to the receiving direction; outside the first focusing elements (24) on both sides a mirror is placed in front of each eye, and the semitransparent reflective surfaces of these mirrors enclose an angle δ 45° ± 15° with the above mentioned optical axis (23), and the intersection line of these reflective surfaces is parallel to the mirror crossing intersection line (4) of the semitransparent reflective surfaces.

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Optical beam-splitter unit and binocular display device containing such a unit

The invention relates to an optical beam-splitter unit and to a display device containing such a beam-splitter unit. The utilisation of mirrors, prisms and semitransparent mirrors for splitting or uniting light beams has been known of for a long time. For example, the subject of USA patent No. 4,924,853, (Jones et al.), is a device uniting two optical paths, containing two prisms one after the other and the reflective surfaces of these direct the beams coming from different directions onto the same optical path. Hungarian patent No. 186 558 also shows a device uniting two optical paths, where a mirror and a semitransparent reflective mirror, one after the other, direct the beams coming from different directions onto the same optical path. These solutions require quite a lot of space since they need two optical units for uniting the optical paths.

The published PCT patent No. WO 85/04961 shows a solution in which an X-cubic prism is used to split the optical paths, and the beam coming from one direction is directed onto two different optical paths by intersecting reflective surfaces. The mass of this device is relatively large, which is disadvantageous in certain cases, for example, in the case of display units fitted on the head.

It is known that in many fields of life it is necessary to enlarge the angle of view of an object source for the viewer,

and there are many different types of technical means for doing this, from simple loupes, through microscopes and laparoscopes to telescopes. In monocular devices the enlargement of the angle of view of the object source can only be seen with one eye. However, looking only with one eye is not natural, after a longer period it can even be disturbing, consequently it is essential to have devices which make it possible for both eyes to view the object source, therefore, a binocular device is needed, different forms of which are known and used.

A common feature of the known binocular devices is that they all contain a beam-splitter unit which splits the beam starting from the object source, such as a computer display fitted on the head, into two and directs it towards the left eye and the right eye. The beam splitting devices are the reflective surfaces of mirrors or prisms, which surfaces can be completely reflective or semitransparent.

Basically a beam can be split in two ways. In the first case the first sections of the two light paths from the object source to the left eye-ground and from the object source the right eye-ground form an angle, because they are travelling, for example, towards two non-transparent reflective surfaces placed next to each other in a V shape, reflecting the beams in different directions. In the second case the first sections of the light paths coincide, and then the splitter unit, which is a semitransparent surface, lets through a part of the beams and reflects the rest in a different direction.

A device representing the first case above, is the subject of Japanese patent description No. 06110013 (Tosaki et al); of the Japanese patent description No. 07287185 (Akishi et al); and USA patent description No. 5,682,173 (Holakovszky et al). In these devices mirrors arranged in a V shape are used to split the light paths. A common disadvantage of these solutions is that as neither of the mirrors are placed opposite the screen, but one of them is placed slightly to the left and the other one slightly to the right, trapezoid distortion occurs, and if the screen is placed too close to the meeting edges of the V-mirrors, then from certain points of the screen the beams do not even get to both mirrors. For this reason, quite a large distance should be kept between the screen and the V-mirrors, according to practical experience it should be twice the screen diagonal, which, on the one part, results in the increase of the constructional size of the device, and, on the other part, the distance between the screen and the lenses coming after the V-mirrors will be large, which reduces the feasible enlargement of the picture, because in the interest of comfortable viewing of the distant virtual picture the screen must be at a distance from the lenses equal to their focal length, and lenses with a greater focal length enlarge to a lesser degree.

In the case of binocular devices, for reasons of symmetry, the micro-display must be placed between the two eyes, and if there is a large distance between the micro-display and the V-mirrors, the device will be protruding like a beak, which, in the case of devices worn on the head, is unfavourable from an aesthetic point of view and because of

the greater pressure exerted on the bridge of the nose. USA patent No. 5,682,173 solves this problem by placing two more mirrors in the light path between the screen and the V-mirrors, and so the light path is reflected twice at an angle of 90°. In the case of patent specification No. 07287185 one single mirror is placed in the light path between the screen and the V-mirrors for the same purpose.

The second case of optical beam-splitting above, when the first sections of the light paths coincide, and then a splitter unit, which has a semitransparent surface, lets through a part of the beams and reflects the rest in a different direction, is dealt with by the above mentioned patent application No. WO 85/04961 (Moss), which uses a well-known optical element, namely an X-cubic prism, the internal surfaces of which are semitransparent reflective surfaces, to split the beam coming from the object source. In this device the distance between the screen and the X-cubic prism can, in principle, be reduced to zero. However, the X-cubic prism is a solid body, and so it is heavy, the production and sticking together of the four right-angled prisms forming the X-cubic prism is expensive, complicated and labour intensive.

The task of the invention is to provide an optical beam-splitter unit which overcomes the disadvantages of the other, presently known solutions designed for solving the same task and which has the smallest possible mass, which can be practically placed as close to the object source as desired, is capable of reflecting any point of the object source in two directions; and the light intensity distribution

of a picture projected with the help of this unit is the same as that of the object source. A further task of the invention is to provide binocular picture display devices made by the use of the above optical beam-splitter unit that are free of the imperfections of the other, presently known devices detailed earlier, and the mass and dimensions of which are small enough to be suitable to be used comfortably as a binocular screen-display fitted on the head.

The beam-splitter unit according to the invention is based on the recognition that two infinitely thin semitransparent mirrors crossing each other in an X-shape are theoretically suitable for the simultaneous solving of the above enumerated four tasks, because they perfectly split and direct in two directions the light beam arriving parallel with their bisector plane and at right angles to their intersection line, partly by transmitting and partly by reflecting it. In reality, however, there are no infinitely thin plates, and overly thin glass plates break, overly thin plastic plates bend, and if they are made thicker, the crossing zone of the mirrors creates an increasingly large shadow band. This crossing zone behaves in a certain – optical – sense as a non-transparent body and throws a strip shadow on the picture, and means increasing reflection fading. This shadow band is extremely disturbing for the person looking at the picture and in most cases – especially in the case of a video picture or computer screen – it is impermissible. Nevertheless, we recognised that if we construct an optical beam-splitter unit made of planoparallel plates at right angles to each other, which touch each other along one edge, and their end faces starting at this edge are optically

flat, and their lateral faces starting at this edge towards the direction of the light beam to be split are semitransparent reflective surfaces, furthermore, if these planoparallel plates abut one or two transparent bodies in a way that the end faces fall on the continuation of its, or their plane surface(s) that are either semitransparent reflective surfaces, or they consist of a semitransparent reflective surface and a completely reflective surface, the above mentioned shadow zone can be completely eliminated, and an optical beam-splitter unit can be made that satisfies all the four requirements of the task.

The beam-splitter unit according to the invention is based further on the recognition that for certain applications – using an adequate holder assuring satisfactory safety against breaking – the beam-splitter unit can be made of planoparallel plates of minimum thickness, assembled together into one unit, X-shaped in projection, which makes the above mentioned shadow band negligible or practically not, or hardly noticeable and in this way it does not disadvantageously influence the proper functioning of the given unit, and at the same time adequately resists breaking or bending.

The binocular picture display unit according to our invention is based on the recognition that it can be constructed with minimal dimensions and mass if

- the light beam starting at the screen of the microdisplay is split by two reflecting surfaces with dimensions corresponding to the screen, that cross each

other in an X-shape, because these direct the beam to the left and to the right in the same volume;

- the optical beam-splitter unit with the smallest mass is that according to this patent application, because the light planoparallel plates have two continuous reflective surfaces;

- the largest degree of enlargement of the microdisplay screen and at the same time the most compact arrangement can be achieved by focusing units placed into the light path near to the two opposite sides of the optical beam-splitter unit;

- the dimensions of the focusing elements are minimal, if their shape is a parallelepiped corresponding to the cross-section of the prism or pyramid shaped light path coming from the parallelepiped shaped screen, and the shape of the mirrors in front of the eyes is a trapezium corresponding to the oblique cross-section of the pyramid shaped light path;

- the mirrors with minimal dimensions in front of the eyes should be placed exactly in front of the pupil, otherwise the complete picture cannot be seen in them; the direction of their horizontal setting should be the optical axis of the focusing elements;

- the external size of the device is the smallest when only the microdisplay unit, the X-mirror optical beam-splitter unit and the focusing elements are surrounded with

a casing, to which the mirrors in front of the eyes are attached with brackets;

- when not in use the size of the device can be further reduced by folding in the jointed mirrors;

- the device that can be miniaturised with the above measures can be so small, that it can be placed crossways in the housing of a portable telephone; and its weight can be so small, that a carrying device is not needed (for example, a helmet, a headband, or spectacle-frame or nose clip.) for mounting it to the head, but it can be fixed to the bridge of the nose with a clip.

- When the device that may be clipped to the bridge of the nose is not in use it is most favourable to wear it as a medallion on a retaining loop similar to a necklace, in this case the device is always “at hand”, similarly to a wristwatch we will be always carrying it, and if necessary it can be put on in one movement;

- By forming the retaining loop as an electric cable and fitting it with two earphones fitted on opposing sections a device providing pictures and sound may be created in the simplest way, because in such a case the mechanical supporting instrument of the earphones is the electric connection cable itself;

- From the point of view of weight, volume distribution and aesthetic reasons it is favourable to place the other electronic units necessary for the operation of the device as

far as possible from the display unit, while being worn in a control unit at the nape of the neck;

- It is favourable to build into the display unit or the control unit either a microdisplay drive circuit, a radio frequency transceiver circuit, a digital television reception circuit, a microprocessor and current supply for the purpose of wireless connection with external sound, data and video signals (e.g. by mobile telephone, portable computer, game console, DVD player, digital television transmitter);

- It is also practical to build a microphone into the housing of the display unit, because then the device may be used as an information technology device terminal or as an independent information technology device; according to our recognition in this way we get a personal communicator that may be worn continuously and which may reach the sensing organs on the head in the following way:

a./ one of the earphones is placed into an ear, and you talk into the microphone at your neck (mobile telephone function);

b./ both earphones are placed into the ears (the sound heard has better acoustic properties; stereo sound possibility), you talk into the microphone at your neck or one held in front of your mouth;

c./ the display unit is clipped onto the bridge of the nose (virtual monitor function);

d./ the display unit is clipped onto the bridge of the nose, one or both of the earphones are placed into the ears (video glasses function, with mono, more acoustic or stereo sound).

We note that as described later in detail the display unit may also be supplemented with a miniature video camera, which extends the functions further.

Based on the above detailed recognition we have solved the set task with an optical beam-splitter unit, which contains transparent planoparallel plates starting at a common intersection line with light reflecting surfaces that diverge towards the light beam to be split, and which optical beam-splitter unit is characterised by that

- the end faces of the planoparallel plates starting also at the common intersection line and that are adjacent to the side faces of the planoparallel plates containing the light reflecting surfaces and which are at right angles to each other, are at right angles to the side faces pertaining to them and these end faces have a plane and optically flat surface;

- at least one such body made of transparent material abuts the planoparallel plates which contain(s) a semitransparent reflective surface, or a surface composed of a semitransparent reflective part and of a completely reflective part and which surface is in the plane of the end faces and start(s) from these end faces continuing them.

An advantageous realisation of the optical beam-splitter unit according to the invention is characterised by that

- it has further second and third planoparallel plates which lie in the continuation of the first and second planoparallel plates with light reflecting surfaces diverging towards the light beam to be split and which abut the first and second planoparallel plates as transparent bodies.

- All the planoparallel plates are made of the same material with equal thickness and refractive index and they are oblate parallelepiped shaped and they join each other along edges parallel to each other and they form, in the section at right angles to the joining edges, an X-shaped unit.

It is practical

a) if the following parts of this beam-splitter unit are semitransparent reflective surfaces:

- the lateral face of the first planoparallel plate towards the neighbouring second planoparallel plate and a section of its opposite lateral face advantageously with a width of

- $$s = \frac{v}{\sqrt{2n^2 - 1}},$$

measured from its edge joining to the fourth planoparallel plate, and in this formula the thickness of the planoparallel plates is v, and the refractive index of their material n;

- the lateral face of the second planoparallel plate towards the first planoparallel plate and a section of its opposite lateral face advantageously with a width s

according to the above formula measured from its edge abutting the third planoparallel plate,

- the lateral face of the third planoparallel plate towards the neighbouring second planoparallel plate, except for its section advantageously with a width s according to the above formula measured from its edge abutting the second planoparallel plate,

- the lateral face of the fourth planoparallel plate towards the neighbouring first planoparallel plate, except for its section advantageously with a width *s* according to the above formula measured from its edge abutting the first planoparallel plate and

b) if the parts given below are completely reflecting

- the section of the lateral face of the third planoparallel plate towards the neighbouring second planoparallel plate, advantageously with width s according to the above formula measured from its edge abutting the second planoparallel plate

- the section of the lateral face of the fourth planoparallel plate towards the neighbouring first planoparallel plate, advantageously with a width *s* according to the above formula measured from its edge abutting the second planoparallel plate.

c) if the parts given below are optically flat:

- the first end face of the first planoparallel plate towards the third planoparallel plate, and

- the second end face of the second planoparallel plate towards the fourth planoparallel plate.

We note here that apart from this all the side faces of all the planoparallel plates are, naturally, optically flat. An optically flat surface is understood as a flat surface the surface roughness of which is less than σ = 10 Å. A semitransparent surface is to be understood as a surface that partly transmits and partly reflects natural or polarized light.

The above defined construction of the optical beam-splitter unit contains a first, a second, a third and a fourth planoparallel plate of thickness v and refractive index n, arranged in an X shape in a way that the two lateral faces of the first and the third planoparallel plate are each bordered by the same planes, and similarly the two lateral faces of the second and the fourth planoparallel plate are each bordered by the same planes, the first end face of the first planoparallel plate towards the third planoparallel plate is in the same plane as the lateral faces of the second and fourth planoparallel plate towards the first planoparallel plate, and it is an optically flat surface, the second end face of the second planoparallel plate towards the fourth planoparallel plate is in the same plane as the lateral faces of the third planoparallel plate towards the second planoparallel plate, and it is an optically flat surface. The lateral face of the first planoparallel plate towards the second planoparallel plate, the lateral face of the second planoparallel plate towards the first planoparallel plate, the lateral face of the third planoparallel plate towards the

second planoparallel plate and the lateral face of the fourth planoparallel plate towards the first planoparallel plate are semitransparent reflective surfaces. The first end face makes the semitransparent reflective surfaces of the second planoparallel plate and the fourth planoparallel plate continuous reflective surfaces, and similarly the second end face makes the semitransparent reflective surfaces of the first planoparallel plate and the third planoparallel plate continuous reflective surfaces, because being optically flat surfaces they prismaticly reflect the beams falling onto them under the limit angle of total internal reflection.

The direction which falls in the bisector plane of the planes of the semitransparent reflective surfaces of the first planoparallel plate and the second planoparallel plate and is at right angles to the intersection line of the above semitransparent reflective surfaces and points towards the intersection line is called the receiving direction, because the X-mirror optical beam-splitter unit described above splits the beam coming from this direction perfectly, and the rectangular area between the external parallel edges of the semitransparent reflective surfaces of the first planoparallel plate and the second planoparallel plate, with a plane at right angles to the receiving direction is called the receiving side, because the object source can be placed here or further away from here.

As the beams going outside of the place where the mirrors cross each other meet a semitransparent reflective surface twice (once they get reflected from it and once they go through it), that is they lose some of their light intensity twice, the same needs to be ensured in the case of the

beams going across the place where the mirrors cross each other, otherwise the part of the projected picture formed by beams filtered only once will be lighter. In practice it appears as a disturbing bright line going across the middle of the picture. According to our recognition this problem can be solved perfectly with the solution according to the invention detailed above.

The subject of this invention also consists of an optical beam-splitter unit with transparent planoparallel plates starting at a common intersection line with light reflecting surfaces that diverge towards the light beam to be split, the essence of which is that it has four planoparallel plates, each is thinner than 0,4 mm, which form, in the cross-section at right angles to the intersection line, an X-shaped unit, where the neighbouring planoparallel plates form an angle of 90°±20° with respect to each other and the planoparallel plates or traditional semitransparent mirrors, or polarisers that completely transmit the light component polarised in the one direction and partly transmit and partly reflect the light component polarised in the other direction. Since the crossing zone is very thin, its shadow is shown blurred, so it is not disturbing, in the case of sufficiently thin planoparallel plates it can not even be seen.

Another optical beam-splitter unit has transparent planoparallel plates starting at a common intersection line with light reflecting surfaces that diverge towards the light beam to be split, and characteristic of this unit is that it has three planoparallel plates, each thinner than 0.4 mm, which form, in the cross-section at right angles to the

intersection line, an X-shaped unit, where end faces of the two planoparallel plates that are shorter that the third are butted up to the middle parts of the faces of the third planoparallel plate so that they form a continuation of each other on each side of the third planoparallel plate, and in which unit (22) the angle between the longer thin planoparallel plate and the shorter thin planoparallel plates is individually 90°±20° with respect to each other and the reflector plates or traditional semitransparent mirrors, or polarisers that completely transmit the light component polarised in the one direction and partly transmit and partly reflect the light component polarised in the other direction.

A further subject of the invention is a binocular picture display device, which has an optical beam-splitter unit, and, furthermore, contains focusing elements and mirrors in front of the eyes, and which is characterised by that its beam-splitter unit is an X-mirror optical beam-splitter unit according to the invention and that two focusing elements are positioned at two opposite sides of the optical beam splitter unit as seen from the direction of the light beam arriving to the semitransparent reflective surfaces of the optical beam-splitter unit – i.e. from the receiving direction – and the common optical axis of these focusing elements is at right angles to the receiving direction, and on both sides, mirrors in front of the eyes are positioned outside these focusing elements, and the reflective surfaces of these mirrors are at an angle δ of 45° ± 15° to the mentioned optical axis, and the intersection line of the planes of the reflective surfaces of these mirrors is parallel to the

intersection line of the mirror-crossing intersection line of the semitransparent reflective surfaces of the optical beam-splitter.

It is favourable if the optical beam-splitter unit, the focusing elements and the mirrors in front of the eyes are encased with a cover which contains a light admitting opening in front of the mirrors in front of the eyes and at the receiving side of the optical beam-splitter unit. Furthermore, it is also advantageous if the optical beam-splitter unit and the focusing elements are fitted in a housing which has a light admitting opening for the focusing elements and which is covered by a cover-plate, and the mirrors in front of the eyes are attached to a first slider and a second slider the stems of which protruding into the housing are toothed racks, which are parallel to each other, and in between them there is a cogwheel that connects them and can move them in opposite directions.

According to a further construction example, the device contains an object source that can be, for example, the screen of a microdisplay. In this case it is favourable if the plane of the microdisplay unit's screen is parallel to the plane determined by the mirror-crossing intersection line and by the optical axis, and is placed at the receiving side of the optical beam-splitter unit, and it is also favourable if the device contains at least one light source lighting the screen of the microdisplay unit, such as an LED, which is placed between the meeting point of the planoparallel plates of the optical beam-splitter unit and the device casing. It can be also practical if that it contains a light source illuminating

through the microdisplay unit from behind, which is placed between the microdisplay unit and the device casing. According to a further construction example on the two sides of the optical beam-splitter unit, in the light path, there is a liquid crystal shutter at right angles to the axis of the focusing elements.

It can be favourable if the device contains two clip plates which for a single unit with the device casing.

Another realisation of the picture display device is characterised by that on the side of the device casing closer to the head of the user of the device there are two hook rails made as one with the device casing, and their generators are parallel to each other; favourably the device contains a clip adapter fitted in between the hook rails, which clip adapter practically consists of a bent plate following the curve of a dent in the device casing, and two clip plates and wing plates the span width of which is equal to the distance between the hook rails.

According to a further construction example the device contains a bearing frame which consists of two spectacle side-arms, a bridge connecting them and, attached to them with joint structures, nose supporting arms attached to the bridge and a device fixing unit; it is advantageous if the bridge is a narrow plate the upper surface of which coincides or is parallel to the plane laid on the spectacle side-arms, and the maximum thickness of which is 1.7 mm, and it is also favourable if the above nose support consists of two nose supporting arms which point downwards, are parallel to each other and are situated at the same distance

from the centre of bridge, and of two nose supporting pads attached to the end of these, and the device fixing unit consists of two U-profile fixing rails which point downwards, are closed at the bottom, are parallel to each other and are situated at the same distance from the centre of the bridge.

Another realisation of the picture display unit is characterised by that it contains at least one microdisplay drive circuit, and/or a radio frequency receiver-transmitter circuit, and/or a power source and/or a microprocessor.

According to a further favourable realisation above one end of the casing there is a CCD picture recording chip sensitive to the infrared range, and above its other end a front lens is placed in a way that the third optical axis of the front lens is at right angles to the detecting surface of the CCD picture recording chip. Above the eye mirror in front of the right eye a reflecting element reflective in the infrared range, transparent in the visible light wavelength range is placed in the light path between the right eye and the detecting surface. Advantageously, above the front lens, there is an infraLED, and its light is guided towards the reflecting element.

It can be also practical if on top of the device casing above the dent in the device casing created for the nose, there is a picture recording CCD chip with a detecting surface in a plane parallel to the plane determined by the optical axis of the focusing elements and the mirror-crossing intersection line, and in front of it, above the microdisplay unit there is a second front lens with an optical axis at right angles to the detecting surface.

In the following construction example we use a reflective microdisplay, which needs to be illuminated at right angles to the plane of the screen. In this instance it is favourable to form the X-mirror optical beam-splitter unit from extremely thin (0.1-0.2 mm thick) planoparallel plates, and to illuminate the screen through these. In the interest of even illumination we place a reflective or focusing element in the space between the two planoparallel mirrors that are further away from the screen (or in the case of a beam-splitter unit formed from three planoparallel plates, between the more distant planoparallel plate and the half-planoparallel plate), which projects the light from the light source, favourably RGB LED triad light, onto the screen. In the interest of the light of the light source illuminating the screen, or directly reflected by the X-mirrors not shining into the eyes, between the light source and the beam-splitter unit we place a polarising plate polarising in the one direction, and in the light path we place a polarising plate on both sides of the beam-splitter unit polarising in the other direction (at right angles to the previous one), so only light beams that have been reflected from the screen the polarity of which has been changed get through the latter two polarising plates.

If the light reflecting surfaces of the X-mirror shaped beam-splitter unit are optical layers that partly reflect and partly transmit the polarised light, in such a case the number of optical surfaces or elements that cause a large degree of light intensity loss is reduced, and due to this as compared to the that of the previous example the intensity of the light reaching the eye is increased by many times, or

we can attain the same light intensity with a much smaller capacity light source consuming much less power.

In a further construction example two ends of a flexible retaining loop are fixed to the opposite ends of the console containing the eye mirrors of the display unit containing the micro display, the optical beam-splitting unit, the focussing elements, the eye mirrors, the display housing and the bridge of the nose clip, in which loop there are electric cables, and to which there is an earphone fixed per branch mechanically and electrically. The length of the retaining loop is longer than the diameter of the wearer's head taken at nose level. In the section of the retaining loop to most distant from the display unit there is a control unit containing the electronics for the microdisplay drive, a power supply, a microprocessor, a radio frequency transceiver circuit and a digital television receiving circuit, in which the one branch of the retaining loop is fixed permanently and the other branch is fixed so that is may be disconnected.

In the following we will describe the invention in detail using the appended figures, which contain favourable realisations of the optical beam-splitter unit; figures helping the understanding of their functioning; as well as examples of advantageous realisations of the binocular picture display unit. The content of the figures is as follows:

Figure 1: the left reflection beam path of three semitransparent mirrors intersecting in an X shape;

Figure 2: the right reflection beam path of known intersecting semitransparent mirrors;

Figure 3: a cross-section sketch of one example of the possible realisations of the optical beam-splitter unit according to the invention;

Figure 4: view of one detail of another realisation form of the optical beam-splitter in cross section showing the left reflection beam path;

Figure 5: sketch of the angle and distance conditions necessary for determining the band of emergent light beams;

Figure 6: a further construction example of the beam-splitter unit according to the invention that is similar to that shown in figure 4., showing the geometric arrangement of the planoparallel plates, in perspective;

Figure 7-8: show further examples of the realisation possibilities of the optical beam-splitter unit in exploded perspective;

Figure 9a: an optical beam-splitter unit according to the invention consisting of four thin planoparalle plates formed by semitransparent mirrors thinner than 0.4 mm in perspective;

Figure 9b: an optical beam-splitter unit the same as that in figure 9a but consisting of three s;

Figure 9c: the enlarged middle part of the unit according to figure 9b in cross-section perpendicular to the face of the plate;

Figure 10: sketch of the arrangement of one realisation of the binocular display unit;

Figure 11: the device as in figure 10, but in perspective;

Figure 12: sketch view of a further realisation of the binocular device according to the invention from above without a casing;

Figure 13: the device according to figure 12, with fixed mirrors in front of the eyes, in a compact casing, viewed from the receiving direction, in perspective;

Figure 14: Another example of the binocular display device with adjustable mirrors in front of the eyes, in exploded perspective;

Figure 15: the moving mechanism of the sliders of the device in figure 14 viewed from above;

Figure 16: the device in figure 15, assembled, in perspective;

Figure 17: the arrangement sketch of another realisation of the binocular display device in perspective;

Figure 18: the clip adapter used with the device shown in figure 17, in perspective

Figure 19: shows a realisation of the binocular display device with its eye mirrors folded in towards the focusing elements, fitted in a camcorder;

Figure 20: the device like in figure 19, also fitted in a camcorder, with its eye mirrors folded out;

Figure 21: a further realisation of the binocular display device according to the invention, fitted in a mobile telephone, with its eye mirrors folded out, in perspective, shown during use;

Figure 22: sketch of a realisation of the device containing a reflective microdisplay unit and LCD shutters, viewed from above;

Figure 23: a realisation of the device connected to a spectacle-frame-like holder;

Figure 24: a realisation of the optical beam-splitter device according to the invention, with a microdisplay driving circuit, radio frequency receiver-transmitter circuit, a power source and a microprocessor; in front-view;

Figure 25: a realisation of the device with an eye movement detecting system, in perspective;

Figure 26: a vision aid and night vision device realised according to the invention in perspective;

Figure 27: shows a sketch from above of a realisation of the binocular device according to the invention, containing a reflective microdisplay and the elements illuminating it from the front;

Figure 28: shows the device as in figure 27 in side view;

Figure 29: shows the binocular display device that can be worn as a necklace while being worn, on the wearer's head and neck, in perspective.

As it can be seen in figures 1 and 2, an X-mirror optical beam-splitter unit has been constructed from planoparallel plates 1, 2, 3 with transparent and semitransparent surfaces as shown by the figures in a cross section perpendicular to the intersection line 4 of the mirror crossing. The figures show only the crossing zone of these reflecting surfaces. The planoparallel plates 2, 3 with their uneven, rough, thin surfaces 2a, 3a produced during

normal cutting processes abut the wide lateral faces of planoparallel plate 1 perpendicularly to these lateral faces. If realised this way, then a zone with a width t, as shown in the pictures 1 and 2, does not take part in the reflection of the light beam denoted by the number 5 and an arrow. For the sake of better lucidity figure 1 shows only light beams a-k going to the left, figure 2 those going to the right.

As it can be seen in figure 1 when beam a reaches the semitransparent reflective surface of plate 1, it is partly reflected back at right angles, with half intensity, and it partly goes inside plate 1 with half intensity. The beam reflected back at right angles reaches the semitransparent reflective surface of plate 2, and is partly reflected back towards the object source, not shown here, with quarter intensity, and after refraction it partly goes inside plate 2 with quarter intensity, and then after being refracted again it leaves to the left – considering the situation shown in the drawing – at right angles to the receiving direction 5, i.e. to the receiving direction denoted by an arrow. Beams b, c and d have the same beam path.

Beam e reaches the semitransparent reflective surface of plate 2 first, and it is partly reflected back at right angles towards plate 1 and from there towards the object source, and after being refracted it partly goes inside plate 2, and disperses on the uneven and rough, that is, not optically flat surface of the end face 2a of plate 2. Beams f and g have the same beam path. When beams h, i, j and k reach the semitransparent reflective surface of plate 2, they are partly reflected back with half intensity towards plate 1 and

from there towards the object source, and partly after being refracted they go inside plate 2 with half intensity, and then after being refracted again they exit from there and reach the semitransparent reflective surface of plate 1, where they are partly reflected back with quarter intensity and exit, and partly after being refracted they go inside plate 1 with quarter intensity. As it can be well seen in figure 1, beams g, f, e arriving in the range between beams d and h do not take part in the picture display on the left, which means a screening – a shadow zone – with width t in the picture.

The reference numbers and signs in figure 2 have been used according to their meaning in figure 1. Beams a-e and i-l take part in the picture display on the right as described above with relation to figure 1, but beams f, g and h arriving in the range between beams e and i disperse on the uneven, rough, not optically flat surface of the end face 3a of plate 3, so in this case, too, a zone with a width t does not take part in the reflection.

Figure 3 shows a construction example of the optical beam-splitter unit according to the invention, which has a first planoparallel plate 6 and a second planoparallel plate 7, and it also has a transparent body 10 made also of a transparent material, and according to this construction example, the thickness of plates 6, 7 differs from each other. Plates 6, 7 join each other at their edges 9a, 9b, and their lateral faces 6a, 7a starting at these 9a, 9b edges and facing each other and made to be semitransparent reflective surfaces are at an angle of $\alpha=90^{\circ}$ to each other. (In figure 3 we show in cross-section perpendicular to the joining edges

9a, 9b the crossing zone of the parts composing the optical beam-splitter unit.) The end faces 6b, 7b that start at the lateral faces 6a, 7a, and are perpendicular to these lateral faces – i.e. the angles β shown in figure 3 are right angles –, are optically flat, which means that they are ground completely smooth and polished until transparent. Surfaces 7a, 6b being in the same plane in consequence of the described and depicted geometrical conditions as well as the surfaces 10a, 10b of body 10 also being in a common plane and in the continuation of the 7a, 6b surfaces are semitransparent reflective surfaces. We note here, that body 10 must not fill the space between the end faces 6b, 7b, this can be empty, too, because, as we well see later, the surfaces of body 10 that abut end faces 6b, 7b – if body 10 is transparent – do not play any role.

According to figure 3 when the light beam arriving from the receiving direction 5 denoted by an arrow reaches the semitransparent reflective surface of planoparallel plate 6 it partly goes inside plate 6 and is reflected on its end face 8 and then exits at its opposite lateral face, is partly reflected back, and reaches the reflective surface of the other planoparallel plate 7 where it is partly reflected back (this is not shown in the figure) and then partly enters plate 7 and after another reflection exits at its opposite lateral face. Light beam a splits into beams a' and a", which are perpendicular to the receiving direction 5, and they exit in opposite directions towards left and right eyes.

The construction example of the optical beam-splitter unit according to the invention shown in figure 4 has been

constructed, in this case, from four transparent planoparallel plates of equal width v, from a first, a second, a third and a fourth planoparallel plate 11, 12, 13, and 14. In order to emphasise the semitransparent reflective surfaces of the lateral faces 11a, 12a of the plates 11 and 12 joining each other at their edges 9a', 9b', they are marked by dots. Plate 11 corresponds to the above mentioned first, plate 12 to the second, plate 13 to the third, and plate 14 to the fourth planoparallel plate according to the definition of these elements. Angles α and β are right angles in this case, too, and the thin end faces 11b, 12b are optically flat surfaces. The optical beam-splitter unit shown in figure 4 differs from that shown in figure 3 in that instead of the transparent body 10 here the above mentioned planoparallel plates 13, 14 join along their edges 15c, 15e to edge 15d of the first planoparallel plate 11, or to edge 15f of the third planoparallel plate 13. The second and third planoparallel plates 13, 14 abut each other along their edges 15g, 15h, and the end faces 13b, 14b of them are not ground, they must not be optically flat, but their lateral faces 13a, 13b falling in the same plane as the lateral face 12a and end face 12b, have a semitransparent, reflective surface, marked in the figure by dots. Space 8 is empty, and filled, for example, with air. Figure 4 shows the crossing zone of the planoparallel plates 11-14 in a section perpendicular to the edges 15a, 15b, and to the others mentioned above.

The light beam arrives at the unit according to figure 4 also from the direction of arrow 5 – from the object source –, surfaces 11a, 12a are facing the object source. We will

describe in the following the path of light beams a-l. Beams a-d are reflected back from the semitransparent reflective surface of the lateral face 12a of plate 12 at an angle of 90°, and they continue their path with half intensity till the surface 11a of plate 11. After being refracted they enter plate 11 with quarter intensity, and after being refracted again they exit at right angles to the receiving direction 5.

After being refracted on the semitransparent reflective surface 11a of the lateral face of plate 11, beam e enters plate 11 with half intensity, and without loss it is reflected back from the optically flat internal surface of the end face 11b of plate 11, and exits at the opposite lateral face 11a' after being again refracted. This exit direction (the direction of the light paths is clearly shown by the arrows drawn on lines a – l) coincides exactly with the exit direction of light beams a-d at any value of refractive index n, since angle γ enclosed by the lateral faces 11a, 11a' of the planoparallel plate 11 with the end face 11b equals 90°, light beam e arrives at the same angle to the lateral face 11a' as the angle at which it entered the from the lateral face 11a into plate 11. Due to this fact light beams d, e, f, g and h also take part in the picture display, and as a result of this the disturbing shadow line in the middle of the picture as mentioned in connection with figures 1 and 2, is eliminated.

In the interest of even light intensity we must also make sure that the beams arriving in the range between beams d and h shown in figure 4 (e.g. beams e, f, g) also meet a semitransparent surface twice, and due to this exit the opposite lateral face 11a of the first planoparallel plate with

a quarter intensity. This can be achieved by providing the mentioned 11a' lateral face's section with a width s where the mentioned beams d, e, f, g exit with a semitransparent reflective coating; this zone 11a" on the lateral face 11a' has been marked with dots. Beams i, j arriving in the range between beams h and k as well as beam k itself go through the semitransparent reflective surface 11a of the first planoparallel plate 11, they are refracted, they enter the first planoparallel plate 11 with half intensity, then after being refracted again at the semitransparent reflective zone 11a" of the lateral face 11a' they exit with quarter intensity. In the interest of their intensity not being reduced any further by another semitransparent reflective surface, a section 11a' with a width s – emphasised by the thick black line – of the lateral surface 14a of the fourth planoparallel plate 14 towards the first planoparallel plate 11 is provided with a completely reflective coating, so the above mentioned beams i, j and k are reflected from this mirror surface 14a' practically without any loss, they exit with a quarter intensity and they take part in the picture display. Finally, starting from beam a towards beam l all light beams after beam k, even beam l, when they reach the semitransparent reflective surface of the lateral face 11a of the first planoparallel plate 11, they are refracted, and they enter the first planoparallel plate with half intensity, then after being refracted again on the opposite lateral surface 11a' of the first planoparallel plate 11 they exit with the same light intensity, and being reflected from the semitransparent reflective surface of the lateral face 14a of the fourth

planoparallel plate 14 they exit with a quarter intensity and take part in the picture display.

As the optical beam-splitter unit shown in figure 4 is symmetrical, the beam path of the beams arriving from the receiving direction marked by arrow 5 and leaving towards the right hand side in figure 4 (not shown in the figure), that is the picture display on the right hand side, will be similar to the picture display on the left hand side like a mirror image; the 12a" and 13a' zones on the lateral faces 12a and 13a have been marked accordingly (section 12a" has a semitransparent reflective surface, while the surface of section. 13a' is completely reflective).

Figure 5 shows those angle and distance conditions on the basis of which width s can be expressed with the thickness v of plate 11 and the refractive index n of its material. In figure 5 beam h reaches the semitransparent reflective surface of the lateral face 11a of the first plate 11 at an angle of arrival ε, it continues its path at a refracting angle ε', and as these are alternate angles, it reaches the meeting point of the opposite lateral face 11a' of the first planoparallel plate 11 and the first end face 15 at the same angle. In the right-angled triangle formed by sides s, v and c:

$$\sin \varepsilon' = \frac{s}{c}$$

$$s = c \sin \varepsilon'$$

Since $n = \dfrac{\sin \varepsilon}{\sin \varepsilon'}$, $\sin \varepsilon' = \dfrac{\sin \varepsilon}{n}$

$$s = c \frac{\sin \varepsilon}{n} = c \frac{\sin 45°}{n} = \frac{c}{n} \frac{\sqrt{2}}{2} = \frac{c\sqrt{2}}{2n}$$

$$c = \sqrt{s^2 + v^2}$$

$$s = \frac{\sqrt{s^2 + v^2} \cdot \sqrt{2}}{2n} = \frac{\sqrt{2(s^2 + v^2)}}{2n}$$

$$2 s n = \sqrt{2 (s^2 + v^2)}$$

$$4 s^2 n^2 = 2 (s^2 + v^2)$$

$$4 s^2 n^2 - 2 s^2 = 2 v^2$$

$$s^2 (4 n^2 - 2) = 2 v^2$$

$$s^2 = \frac{2 v^2}{4 n^2 - 2} = \frac{v^2}{2 n^2 - 1}$$

$$s = \frac{v}{\sqrt{2 n^2 - 1}}.$$

In reality the light beams starting at the object source do not only arrive from the receiving direction 5, but also from many different directions within a certain angular range. The optically flat end faces 11b and 12b can be

proved to play a complete part in the image creation, but their surfaces have to be mercury plated, because without this there are light beams that arrive at an angle smaller than the critical angle for total reflection, and they simply exit. For light beams that are not parallel to the receiving direction the relation

$$s = \frac{v}{\sqrt{2\,n^2 - 1}}$$

is not valid, different angles of incidence involve slightly different widths, nevertheless their average is equal to s, so in the practice it is practical to use this width anyway.

Figure 6 shows the complete optical beam-splitter unit according to the invention constructed as in figure 4, but shown in smaller scale, in perspective; the reference numbers have been used according to their previous meaning. The planoparallel plates 11, 12, 13 and 14 are rectangular bodies raised on the lateral sides of an ABCD A'B'C'D' quadratic prism. The first one of the two continuous reflective surfaces crossing each other in an X shape (for the sake of lucidity here it is not accentuated by technique of drawing and it is not numbered, but clearly shown in figure 4 and well explained in the text)

- is formed by the semitransparent reflective lateral face of the first planoparallel plate 11 defined by the corner points JAA'K,

- the prismaticly reflecting second end face of the second planoparallel plate 12 defined by the corner points ABB'A',

- the semitransparent reflective surface part of the lateral face of the third planoparallel plate 13 defined by the corner points HNOH', and

- the completely reflecting BHH'B' surface part of the lateral face of the third planoparallel plate 13 defined by the corner points BHH'B', while the second one

- is formed by the semitransparent reflective lateral face of the second planoparallel plate 12 defined by the corner points ALMA',

- the prismaticly reflective first end face of the first planoparallel plate 11 defined by the corner points ADD'A',

- the completely reflective DFF'D' surface part of the lateral face of the fourth planoparallel plate 14 defined by the corner points DFF'D' and

- the semitransparent reflective surface part of the lateral face of the fourth planoparallel plate 14 defined by the corner points FPOF'.

- Also, in the interest of even light intensity a surface part of the rear lateral face of the first planoparallel plate 11 defined by corner points EDD'E' and a surface part of the lateral face of plate 12 defined by corner points BGG'B' are given a semitransparent reflective coating.

Figure 7 shows a possible practical way of attaching the planoparallel plates 11-14 – made of a transparent material, e.g. glass – of the optical beam-splitter unit 22, X-shaped as seen from above, according to the construction shown in

figures 4-6 to each other. According to this the X-shaped unit fits into the X-shaped slots 18 engraved into the surfaces of bearing plates 17 and 19 with thickness v'>v (only slot 18 made on the surface of bearing plate 17 is shown in the picture). Bearing plates 17 and 19 are parallel to each other, and the slots are engraved in their surfaces facing each other. The width of the slots is practically the same as the width v of plates 11-14, and their depth fits also the size of the plates fitting into them. The planes of bearing plates 17 and 19 are perpendicular to the planes of the planoparallel plates.

In the case of the above construction example the lower of the two square, from above, bearing plates 17, 19 serves as base plate, the upper as cover plate. Plates 11-14 can be stuck in the slots 18 – falling geometrically into the diagonals of the bearing plates – along the surfaces of their end faces perpendicular to their reflecting surfaces. In this construction plates 11-14 join along edges 9 in a way that the four planoparallel plates touch each other along one edge each, and their end faces encase an empty quadratic prism shaped area 8, a penetration prism.

Figure 8 shows the possibility of the realisation of a further practical construction of the optical beam-splitter unit. According to this plates 11 and 13 as well as the planoparallel plates 12 and 14 are made in one piece in a way that they are connected at one of their ends by a part 20 of width v, length v, depth v, made of the same material as the plates itself. This construction results in a downward open gap 20a of v·v·v cross-sectional size between plates 12

and 14, while an upward open gap of the same size 20b is created between plates 11 and 13. (Of course, gaps 20a and 20b are open also at their sides). In other words, the lateral sides of the two pairs of plates created in one piece are in one plane in pairs, and they are at a distance v from each other, connected by a part 20 of a size of v·v·v. The pairs of plates 11, 13 and 12, 14 with the gaps 20a and 20b are guided into each other and fixed to each other by a tight fit or stuck to each other in a known way on their touching surfaces. A part of the optical beam-splitter unit created in this way and shown in the lower part of figure 8, with width v measured from the edge surfaces at right angles to the mirror crossing intersection line 4 does not take part in the picture display, because the part of the prismaticly reflective second end face 16 of the second planoparallel plate 12 and the prismaticly reflecting first end face 15 of the first planoparallel plate 11 remaining free after the plates have been guided into each other is only m-v long.

According to another construction not shown in the figure the square shaped planoparallel plates made of a transparent material are injection moulded plastic plates, and on their edge surfaces at right angles to the intersection line of the reflective surfaces they have locking pins with an axis parallel to the above intersection line, and so they can be fitted into the holes on the receiving optical device.

There are many other ways of attaching the planoparallel plates of the optical beam-splitter unit according to the invention to each other. If the thickness of

the planoparallel plates is significantly smaller than the diameter of the pupil, then the edges with a width s of the planoparallel plates do not need to be made reflective or provided with a semitransparent reflective coating, because instead of the above mentioned bright line only a slightly lighter line will appear in the picture, and in certain applications this is not so disturbing that it would question the applicability of the device. If the thickness of the planoparallel plates approaches the theoretical case of "infinitely thin", then the semitransparent reflective surfaces of the X-mirror optical beam-splitter unit form a continuous surface even without the above mentioned optically flat end faces, and the shadow of the crossing zone cannot be noticed in the picture. As planoparallel plates which are so thin, one or two tenths of a millimetre thick at the maximum, they are very fragile, they can be fixed, for example, between rigid bearing and cover plates with slots as shown in figure 7. Such a construction is shown in figure 9a. Here the bearing plates 17, 19 are held together on one side by a rib or back-plate 21, placing, in this way, the 0.1 mm thick planoparallel plates in a U-shaped yoke. The planoparallel plates fixed in this yoke form an X-shaped unit as seen from above. Figure 9a shows plates 11', 12', and 13' fitted, held in the x-shaped slots in the lateral faces of plates 17, 19, facing each other. On figure 9b the crossing zone of the planoparallel plates 11', 12' and 13' according to figure 9a has been shown enlarged in cross-section perpendicular to the mirror-crossing intersection line. As can be seen the bean-splitter unit according to the invention consists of three plates, in such a way that the

end faces of planoparallel plates 11' and 13' are butted up against the middle part of the thin planoparallel 12', which is twice as long as the others, so that they are on opposites sides and are a continuation of each other.

Figures 10 and 11 show the optical beam-splitter unit 22, which is X-shaped in top view, constructed from four transparent planoparallel plates as can be seen, for example, in figures 4 and 6, and denoted here by a single reference number. There are two first focusing elements 24 placed on both sides of the optical beam-splitter unit. The semitransparent reflective surfaces of unit 22 are marked with dotted line. The common optical axis 23 of the first focusing elements 24 crosses the mirror-crossing intersection line 4 of the planoparallel plates, and it falls into the bisector plane of the semitransparent reflective surfaces. The first focusing elements 24 are multi-element composite achromatic lens systems – in this particular case they have four elements, from the direction of their optical axis 23 they are rectangular, that is they are bordered by planes, and these planes coincide with the overall planes of the X-mirror optical beam-splitter unit 22 parallel to the optical axis 23 of the first focusing elements 24. Two mirrors in front of the eyes 25 are positioned on the two sides of the first focusing elements 24, and the reflective surfaces of the mirrors are at an angle of 45° ± 15° to their optical axis 23. The intersection line of the planes of the reflective surfaces of these mirrors (not shown in the figures, it is outside the surface of the drawing) is parallel to the mirror-crossing intersection line 4. In figure 10 we marked the path of an incident beam a which is guided by

the semitransparent surfaces of the X-mirror optical beam-splitter unit 22 (see also figure 4) to the left eye 26 and to the right eye 27 of the person using the device partly by transmission and partly by reflection. The lenses of the focusing element 24 forming a four-element achromatic lens system can be attached to each other by sticking them together. As we have already mentioned, the first focusing elements 24 are rectangular from the direction of their optical axis 23, that is they are bordered by planes, and these planes coincide with the two edges of the optical beam-splitter unit 22 that are the closest to the receiving side and also with its two edges that are most distant from the receiving side, and also with the lower and upper border surfaces that are perpendicular to the mirror crossing intersection line 4. The mirrors in front of the eyes 25 are plane glass mirrors with their faces towards the first focusing elements 24 being mercurated. Their shape is a trapezoid to fit the shape of the light path, their two edges are parallel to the mirror-crossing intersection line 4, their other edges are convergent in the direction of the edge closer to the eye.

The binocular picture display unit according to figures 10 and 11, due to its small space demand, small weight and compact construction, can be used favourably as a binocular display unit for instruments and optical devices based on enlarging, such as endoscopes, laparoscopes, microscopes and telescopes. The elements of the device are attached to each other practically, either with their own frame or case, or with the frame or case of the above mentioned instruments and optical devices.

The picture display tool according to figures 12 and 13 has also an X-mirror optical beam-splitter unit 22 (figures 4 and 6) with two first focusing elements 24 on its both sides, and a further mirror in front of the eyes 25 on both sides similarly to the construction shown in figures 10 and 11. These devices are encased by a casing 28 which has light admitting openings 28a, 28b of a size corresponding to the size of the light path, located in front of the mirrors that are in front of the eyes 25 and on the side of the X-mirror optical beam-splitter unit 22 facing the receiving direction 5. In the light admitting opening 28a there is a focusing element 29. As can be seen in figure 13, the casing 28 encases the optical elements of the device in a compact way; the position of the openings 28a and 28b can be seen well also in figure 13. The device shown in figures 12, 13 is a binocular loupe according to its characteristics, and looking in its light admitting openings 28a, 28b the user can see with both eyes the enlarged picture of the object source being at the focal length or closer in the receiving direction in the trajectory of the light. The object source that is exactly at the focal length seems to be infinitely distant, and reducing the distance the virtual distance of the virtual picture is also reduced and any desired virtual picture distance, for example, the usual half meter used for viewing objects in the hands, can be set. The centres of the mirrors in front of the eyes should be approximately equal to the distance between the pupils of the person using the device in order to avoid distortion and to be able to see the whole picture, and for this purpose one needs devices with different eye mirror distances, according to the changing

distance of the human pupils that is in most of the cases between 55 and 70 mm. In practice it is enough to produce a binocular loupe with 3 mm increments, that is, with six different distances (with 55, 58, 61, 64, 67 and 70 mm eye mirror centre distances), and the person using the device can use that best fits his or her size. An advantage of this construction is that it does not contain any moving parts, it does not need to be adjusted, the disadvantage is that it has to be produced in six different sizes and the same device cannot be used by persons of different pupil distance.

The device according to figures 14-16 is a binocular loupe where the X-mirror optical beam-splitter unit 22, as shown, for example, in figures 4 and 6, with pairs of first focusing elements 24 on its both sides is encased in a casing 30 which has light admitting openings at its two ends and in the middle of one of its longer sides, and there are ledges 31 on its internal side walls made by wall-thinning, at the ends of the side walls there are threaded fixing holes 32. From the top the X-mirror optical beam-splitter unit 22 and the first focusing elements 24 are closed with an insert plate 33 supported on the ledges with its projections, and in the centre of the insert plate 33 there is a hole 34, and on its two opposing sides there are two pegs 35. On the above projections there are flanges 36 which form a constraint path from the external side for the stem of the first slider 37 and the second slider 38 moving above the insert plate 33. On the internal sides of the first slider 37 and the second slider 38 facing each other the constraint path is created by a cogwheel 39 and the pegs 35 of the insert plate 33. When the cogwheel 39 turns, it

engages into the tooth racks 40 made in the stems of the first slider 37 and the second slider 38, and it moves the first slider 37 in one direction and the second slider 38 in the opposite direction. The cogwheel 39 has one axle, and it is made in one piece with the grooved wheel 41 the axle 42 of which fits into the hole 34 of the insert plate 33 downwards, and into the blind hole situated in the centre of the cover plate 43, not marked here, upwards. The cover plate 43 is of the same size as the housing 30, the four open-end holes 44 in its four corners have the same axes as the four holes 32 of the housing 30, and with the screws 45 the cover plate 43 can be fixed to the housing 30.

According to figure 15, when the grooved wheel 41 is turned in the first direction 46, the cogwheel 39 made in one piece with it moves the first slider 37 in the second direction 47 and the second slider 38 in the third direction 48. The movement is stopped by the projection at the end of the tooth racks 40 in the one direction, and by the stubs 34 at the tapered ends of the first slider 37 and the second slider 38 in the other direction.

According to figure 16 the cover plate 43 of the assembled device leaves the edge of the grooved wheel 41 free on certain sections, and if it is turned by the tip of a finger, the mirrors in front of the eyes 25 fitted on the first slider 37 and the second slider 38 move at the same time either towards the housing 30, or in the opposite direction.

Since in the construction according to the previous description the mirrors in front of the eyes are mounted onto sliders inside the casing, which makes the adjustment

of the distance between the mirrors in front of the eyes possible according to the pupil distance, along the direction parallel to the optical axis of the focusing elements, so the same device can be used by everybody. The sliders are cogwheels with their axes parallel to each other, forced to a rectilinear motion by a constraint path, and connected to each other by a cogwheel with an axle fixed to the casing, and placed in between the cogged sides of the cogwheels to form a system, and by means of this by turning the adjusting grooved wheel on the same axle as the cogwheel the two sliders and with them the two eye mirrors move parallel to each other, but in opposite directions, facilitating the positioning of both mirrors in front of the eyes. Since the semitransparent reflective surfaces of the optical beam-splitter unit reduce the light intensity to a quarter of the original one, it is practical to illuminate the object source for compensating the reduction and to ensure better illumination, so it is favourable if the device contains a light source directed at the object source, for example, a white light emitting LED and a small sized power source. The use of a binocular loupe is more advantageous than the use of a monocular one, because it better suits the human way of seeing using two eyes, you do not need to close one eye, or squint with it, so you can work comfortably with this binocular device when performing long or often-repeated medical, cosmetic investigations and precision-mechanical work. A binocular loupe used especially for work purposes is best used fitted to the head of the person using it, with the help of a headband, spectacle frame or nose-bridge clip. It is advantageous if the binocular loupe is connected to the

headband or spectacle frame with an articulated mechanism, so in breaks from using the device it can be pushed up over the forehead.

We shall describe in the following constructions containing an object source. This object source is located in front of the receiving side of the X-mirror optical beam-splitter unit according to the invention, in a plane at right angles to the receiving direction. The object source can be non-transparent, translucent or transparent, lit or lit through by the external environmental light, lit or lit through by a light source or luminous by itself. According to its concrete effective form it can be a microfilm frame, diapositive film frame, paper picture, drawing or printed text, electronic screen or other object source.

According to the construction example in figures 17 and 18 in front of the receiving side of the X-mirror optical beam-splitter unit 22 of the picture display device functioning as a virtual display, on its side facing the arrow 5 indicating the receiving direction there is a microdisplay unit 49 as an object source with a light emitting screen, 49a, and the unit 22 is enclosed from two sides by two focusing elements on each side, and outside the focusing elements there is one mirror in front of each eye, arranged as in the construction examples in figures 10 and 11, 12 and 13, as well as in figures 14-16. The plane of the screen 49a is parallel to the mirror-crossing intersection line 4. The screen 49a is supplied with the necessary voltage and electric signals through a cable 50, from a voltage and video-signal source not shown here. The X-mirror optical

beam-splitter unit 22, the first focusing elements 24 and the microdisplay unit 49 are built in a device casing 51 which contains light admitting openings 51a, 51b between mirrors 25 and the pairs of first focusing elements 24, and on its side opposite the microdisplay unit 49 between the planoparallel plates of unit 22 opposite to the microdisplay 49, there is a dent 52 using the space not falling in the light path, to suit the bridge of the nose. On the two sides of the dent 52 there are hook rails 53 the generator of which is parallel to the mirror-crossing intersection line 4 of the X-mirror optical beam-splitter unit 22, and due to these hook rails 53 the device can be put on a bearing plate, not shown here, with a width suiting the distance between the bays of the hook rails 53. For example, if the mentioned bearing plate is in the middle of a spectacle frame, the device can be pulled onto this, and if it fits exactly, the device can be moved up and down the bearing plate and it can be stopped anywhere, for example, exactly in front of the pupils.

The mirrors in front of the eyes 25 are each attached to a mirror holding unit 54, which are connected to the sliders 56 by the help of joints having axes parallel to the mirror-crossing intersection line 4 of unit 22, which joints are moved by the cogwheel-toothed rack mechanism that can be studied in detail in figures 14 and 15 and also explained above in details (not shown here), if the grooved wheel 57 is turned with the tip of a finger of the user of the device. The mirror-holding units 54 with the brackets stretching before the eyes, connected to joints 55 can be folded in together with the mirrors 25 on them towards the first focusing elements 24, thus significantly reducing the volume of the

device. The real dimensions of the device with its mirrors folded in can be so small (e.g. 1.5x2.5x3.5 cm) that it can be placed after usage in the hollow made in the casing of any of the video signal sources (not shown here) for this purpose, or it can be connected to the connector made on the casing 51.

The clip adapter shown in figure 18, and marked as one unit with the reference number 58 consists of a bent plate 59 following the curve of the dent 52 in the device casing 51 according to figure 17, clip plates 60 continuing this curve, and elastic wing plates 61 protruding on two sides towards the hook rails 53. The clip adapter 58 is attached to the device casing 51 so that the ends of the wing plates 61 are guided in between the hook rails 53. In the figure the position of the clip plates 60 with respect to the user's bridge of the nose is shown with a broken line, the clip adapter can be fixed by forcing open the elastic plates. The clip plates 60 in their position drawn by dotted lines fit tightly to the bridge of the nose from both sides due to their elasticity like a pince-nez. The clip plates 60 can also be made in one piece with the device casing 51, in this case the clip adapter 58 and the stud 53 are not needed.

A light emitting object source can be built into the device according to figure 17 as a virtual display unit, in front of the receiving side of the X-mirror optical beam-splitter unit, such as an AMEL (active-matrix electroluminescent), OLED (organic light-emitting diode), FED (field-emission display), AMOLEP (active-matrix organic light-emitting polymer), OEL (organic

electroluminescent) or VFOS (vacuum-fluorescent-on-silicon) micro display unit, which is supplied with the voltage and the electric signals needed for its operation through a cable 50 – as mentioned before – from a video-signal source carried by the person using it (mobile telephone, communicator, palmtop computer, DVD player, video-game, video-camera recorder, digital camera, etc.). The device according to the invention can also be built into the above video-signal sources, in this case the person using the device must lift the video-signal source to his/her eyes and look into the eye mirrors of the binocular display unit. The use of a combined solution can be advantageous when the binocular display unit can also be viewed fixed to the video signal source, and when taken out of it, can also be attached to the head, especially in the case of mobile telephones, video cameras and digital cameras. Such a construction is shown in figures 19 and 20, where the device according to the invention as shown in figures 10 and 11 is applied as a viewfinder, as a monitor, built in the end of a palmcorder 62 video-camera opposite to the objective 63, so that the optical axis 23 of the first focusing elements 24 (figure 20), not shown here, is at right angles to the second optical axis 64 of the objective 63. When not in operation, the binocular picture display device is placed in a hollow made inside the camera casing, with the mirrors in front of the eyes 25 folded in, and this hollow is closed by a cover 65. When the sliding button 66 is pulled back, the device in mechanical connection with it slides out of the hollow on a constraint path created by the camera casing, opening down the cover 65 in front of it, and the mirrors in

front of the eyes 25 open out completely with the help of spring joints 55 (See figure 17). Instead of this mechanical driving mechanism another version can be constructed where the device is pushed out and pulled back by an electric motor at the push of a button.

Consequently the picture display device according to the invention can be used as a viewfinder/monitor in video cameras and their versions that also contain a picture-recording device (camcorders).

Traditionally two types of viewfinder are used: one of them is a normal one eye monitor where the microdisplay screen built in the video-camera is to be viewed with one eye through a front lens, which is not natural, tiring and makes the other eye squint. In the other case on the casing of the video-camera there is a flat panel monitor which can be folded out, but it is small in order to suit the size of the portable video-camera, it can be as big as half of a palm at the maximum, and it cannot be seen very well, the details of the pictures can hardly be seen.

In the construction example of figures 19 and 20 the picture of the device can be viewed locally by opening out the mirrors in front of the eyes, or the device can also be taken out of the video-camera and fixed on the head. As modern palm-sized video-cameras (palmcorders) are thinner than the distance between the pupils, when such a video-camera is lifted up in between the two eyes it cannot be seen with both eyes at the same time, as you should go cross-eyed to do that, only the eye mirrors with their bearing piece folded out in front of the eyes are screening

for both eyes. This results in an optical effect that in all directions around the non-transparent, bright, contrasted virtual picture seen in the mirrors in front of the eyes there is a clear view at least for one of the eyes, that is the video-camera practically disappears from the field of view. For those making a recording it is especially advantageous that while they are looking at the picture of the viewfinder with both eyes, they see the whole area around the picture, and nothing is screened from the view.

According to figure 21 the device according to the invention, as a viewfinder, is built in the end of a mobile telephone 67, in other words the device is the viewfinder of a mobile telephone. The virtual picture is displayed after the mirrors in front of the eyes 25 have been opened completely mechanically or by a motor.

Since the mobile telephone's own small screen is suitable for displaying only little picture or text information, for example an Internet web-site or a whole E-mail page cannot be read at this size. For this reason it is advantageous to build the device according to the invention in the casing of the mobile telephone or connect it to the mobile telephone's battery charger connection end as an external adapter. According to figure 21 in the present construction the device is placed in the end of the mobile telephone with the mirror in front of the eyes folded in, and by folding out the mirrors in front of the eyes and lifting them up in front of the eyes it can be viewed locally, or it can be taken out of the casing of the mobile telephone and attached onto the head.

The construction of the picture display device according to the invention shown in figure 22 contains an emissive type, for example, an OLED 49 microdisplay. This construction is similar to that shown in figure 17, so the reference numbers used there are also used in figure 22. In the light path between the X-mirror optical beam-splitter unit 22 and the first focusing elements 24 there are liquid crystal shutters 69 which become dark or transparent influenced by the voltage, with the picture frequency of the microdisplay unit 49, in alternating phases.

According to the construction shown in figure 23 a picture display device, favourably the device according figure 17 is attached onto the user's head with the help of a bearing frame 70, which consists of two metal spectacle side-arms 71, a metal bridge 73 connecting and attached to them with joint structures 72, two nose supporting arms 74 soldered to the bridge 73, two nose supporting pads 75 attached to the end of the nose supporting arms 74, and two U-profile clamping rails 76 closed at the bottom, soldered to bridge 73, in which the two overhanging ends of the lateral face of the device casing 51 opposite the microdisplay unit 49 can be guided and slid up and down. The bridge 73 is a narrow plate of a similar material and profile to that of the spectacle side-arms 71, its upper surface coincides with or is parallel to the plane laid on the spectacle side-arms 71, and due to this, when it is worn by the user, it is seen edgeways, the plate is maximum 1.7 mm thick, and as it is smaller than the diameter of the pupil, it causes only a translucent shadow line, which does not disturb the view. In another version the nose supporting

arms 74 are tubular shafts of adjustable length, not shown here, and with their help the distance of the nose supporting pads 75 and the bridge 73 can be set, and by this the device attached to the bridge 73 and its mirrors in front of the eyes 25 can be set in front of the eyes vertically.

According to figure 24 between the X-mirror optical beam-splitter unit 22 according to the invention (figures 4 and 6) or the pairs of first focusing elements 24 and the device casing 51 there is a microdisplay driving circuit 77, a radio frequency receiver-transmitter circuit 78, a power source 79 and a microprocessor 80. Using these arrangements the device can be as compact as possible, no wires are needed for connecting it to the control signal, video signal and power sources and the necessary computations, picture processing and other tasks can be solved locally.

The device equipped with a system detecting the movements of the eye according to the construction example in figure 25, corresponds basically to the device in figure 17, with the exception that here above one end of the casing 51 there is a CCD picture recording chip 81 sensitive in the infrared range, and above its other end a front lens 82 is placed in a way that the third optical axis 83 of the front lens 82 is at right angles to the detecting surface 84 of the CCD picture recording chip 81. Above the eye mirror 25 in front of the right eye 27 a reflecting element 85 reflective in the infrared range, light-admitting in the visible light wavelength range is placed, made in one unit with the mirror in front of the eye 25, in a size and at an angle so

that it reflects the beams starting from the pupil 86, iris 87 and sclera 88 of the right eye 27 onto the detecting surface 84 through the front lens 82. In the interest of even lighting of the right eye 27, above the front lens 82 there is an infraLED 89 placed at an angle that the infrared beam starting from it is projected onto the reflecting element 85, and after it is reflected back from there, it is projected onto the right eye 27. The CCD picture recording chip 81, the front lens 82 and the infraLED 89 are encased with a casing, not shown here, which contains a light admitting opening at the front lens 82, and which is combined with the device casing 51.

The picture detected by the CCD chip 81 is analysed with the help of a picture processing program by a microprocessor built into the device or connected to it with a cable, and from the movement and position of the contour of the iris and/or the pupil it calculates the point on the screen of the microdisplay unit where the eye looks, and displays a cursor there, and it also detects the momentary hiding of the contour of the iris and/or the pupil by the eyelid (blinking), and it clicks interpreting it as a command. In order to increase the contrast of the dark pupil and the lighter iris, or the iris and the white of the eye (sclera) independently from the external light conditions and the disturbing sparkling of the eyes, the iris and its immediate environment should be preferably lit with infrared light, because the users do not see it, they are not disturbed by it.

The construction example presented in figure 26 is a vision aid and night vision device and is basically the device

according to figure 17, but here on top of the device casing 51, above the dent 52 created for the nose, there is a CCD picture recording chip 90, above the microdisplay unit 49 there is a front lens 91 placed in a way that the optical axis 92 of the front lens 91 is at right angles to the detecting surface 93 of the CCD chip 90. The CCD picture recording chip 90 and the front lens 91 is encased with a cover, not shown here, which contains a light admitting opening at the front lens 91 and is combined with the device casing 51. The detecting surface of the picture recording CCD chip 90 falls in a plane parallel to the plane defined by the optical axis of the first focusing elements 24 and the mirror-crossing intersection line of the beam-splitter unit 22 (see intersection line 4 in figure 17). The picture recorded by the CCD chip 90 appears on the screen 49a of the microdisplay 49 (not shown in figure 26) with a light intensity that – depending on the actual setting – is multiple of the original intensity, and in this case the utilisation of this device is advantageous for people with reduced vision capability, who cannot adequately orient themselves under weak illumination conditions, for example, in the evenings or in half-light. If the CCD is sensitive in the near infrared range, displaying this infrared picture on the screen of the microdisplay makes the orientation possible of the person using the device even in total darkness provided that the area is irradiated by an infrared light source.

As can be seen in figures 27 and 28, the microdisplay 49 placed at the receiving side of the element 22 made of very thin semitransparent mirrors (also see figures 9a.-9c.) is a reflective type, the display screen 49a of which is

illuminated from the front by the Fresnel lens 94 located on the other side (as seen from the display) of the element 22, the greater part of which or all of it is located in the space between planoparallel plates 13 and 14 and this Fresnel lens 94 makes the light-beam of the LED 95 parallel and projects it to the screen 49a through the first polariser 96 and the semitransparent surfaces of element 22. The light beam arrives from the screen 49a to the eye through the X-mirror element 22, the second polariser 97a or third polariser 97b, the first focusing element 24 and the eye mirror 25.

According to the construction example in figures 29 view of a binocular display unit which contains eye mirrors 25a, a microdisplay 49b placed between the eye mirrors 25a, a beam-splitting unit 22a, focusing elements 24a, a display housing 56a, a microphone 108, a nose clip 60a and a flexible retaining loop 105 that is longer than the diameter of the head of the wearer at nose level it contains. The retaining loop 105 is formed in part of wholly as electric cable, contains two earphones 106, a control unit 107, and either the control unit 107 or the display housing 56a contains any of the following: the microdisplay drive electronics, a radio frequency transceiver circuit, a digital television receiving circuit, a microprocessor and a power source.

An advantage of the optical beam-splitter unit according to the invention is that it has a minimal space demand and minimal mass, that it can be placed as close to the object source, as you like, and the picture of the device is of

exceptional quality. The advantages of the binocular picture display device are similarly its small space demand and its small mass, that it is simple to manufacture and the very many application possibilities.

The invention is not restricted to the construction examples of the unit, or of the device cited here, but in the area of the protected solutions defined by the claims many different constructions of it can be realised. So, for example, in the interest of enlarging the image further focusing elements and semitransparent or completely transparent mirrors may be placed.

Claims

1. Optical beam-splitter unit which contains transparent planoparallel plates 6, 7; 11,12 starting at a common intersection line 4 with light reflecting surfaces that diverge towards the light beam to be split, characterised by that

- the end faces 6b, 7b; ADD'A', ABB'A' of the planoparallel plates 6, 7; 11, 12 starting also at the common intersection line 4 and that are adjacent to the side faces 6a, 7a; AJKA', ALMA' of the planoparallel plates 6, 7; 11, 12 containing the light reflecting surfaces and which are at right angles to each other, are at right angles to the side faces 6a, 7a; AJKA', ALMA' relating to them and these end faces 6b, 7b; ADD'A', ABB'A' have plane and optically flat surfaces;

- at least one such body 10; 13, 14 made of transparent material abuts the planoparallel plates 6, 7; 11, 12 which contains a semitransparent reflective surface, or a surface composed of a semitransparent reflective part and of a completely reflective part 10a, 10b; DPOD', BNOB' and which surface is in the plane of the end faces 6b, 7b; ADDA', ABBA' and starts from these end faces 6b, 7b; ADD'A', ABB'A' continuing them.

2. Optical beam-splitter unit as in claim 1, characterised by that

- it has further third and fourth planoparallel plates 13, 14 which lie in the continuation of the first and second planoparallel plates 11, 12 with light reflecting surfaces

AJKA'; ALMA' diverging towards the light beam to be split and which abut the first and second planoparallel plates 11, 12 as transparent bodies;

- all the planoparallel plates 11, 12, 13, 14 are made of the same material with equal thickness v and refractive index n and they are oblate parallelepiped shaped and they join each other along edges 15a-15b; AA', BB', CC', DD' parallel to each other and they form in the cross-section at right angles to the joining edges an X-shaped unit.

3. Optical beam-splitter unit as in claim 2, characterised by that

a) the following parts of it are semitransparent reflective surfaces:

- the 11a; AA'KJ lateral face of the first planoparallel plate 11 towards the neighbouring second planoparallel plate 12, and a 11a"; DEE'D' section of its opposite lateral face 11a' advantageously with a width of

$$s = \frac{v}{\sqrt{2n^2 - 1}} ,$$

measured from its edge 15c, 15d joining the fourth planoparallel plate 14, and in this formula v is the thickness of the planoparallel plates, n the refractive index of their material;

- and the 12a; ALMA' lateral face of the second planoparallel plate 12 towards the first planoparallel plate 11 and a 12a"; BGG'B' section of its opposite lateral face

12a' advantageously with a width s according to the above formula measured from its edge 15e, 15f; BB' abutting the third planoparallel plate 13;

- the 13a; BNOB' lateral face of the third planoparallel plate 13 towards the neighbouring second planoparallel plate 12, except for its 13a"; BHH'B' section advantageously with a width s according to the above formula measured from its edge 15e, 15f ; BB' abutting the second planoparallel plate 12;

- the 14a; DPQD' lateral face of the fourth planoparallel plate 14 towards the neighbouring first planoparallel plate 11, except for its 14a'; DFF'D' section advantageously with a width s according to the above formula measured from its edge 15c, 15d; DD" abutting the first planoparallel plate 11; and

b) the following parts of it are completely reflective surfaces:

- the 13a'; BHH'B' section of the 13a; BNOB' lateral face of the third planoparallel plate 13 towards the neighbouring second planoparallel plate 12, advantageously with a width s according to the above formula measured from its edge 15a, 15b abutting the second planoparallel plate 12;

- the 14a'; DFF'D' section of the 14a; DPQD' lateral face of the fourth planoparallel plate 14 towards the neighbouring first planoparallel plate 11, advantageously with a width s according to the above formula measured from its edge 15c, 15d; DD' abutting the second planoparallel plate 12; and

c) the following parts of it are optically flat surfaces:

- the 11b; ADD'A' end face of the first planoparallel plate 11 opposite the end face 13b; CBB'C' of the third planoparallel plate 13; and

- the 12b; ABB'A' end face of the second planoparallel plate 12 opposite the end face 14b; CDD'C' of the fourth planoparallel plate 14.

4. Optical beam-splitter unit as in any of claims 1 to 3, characterised by that the end faces 6b, 7b; ADD'A', ABB'A' are mercury plated on their outer surface.

5. Optical beam-splitter unit which contains transparent planoparallel plates starting at a common intersection line 4 with light reflecting surfaces that diverge towards the light beam to be split characterised by that it has four planoparallel plates 11, 12, 13, 14 that are each thinner than 0.4 mm, and which form in the cross-section at right angles to the intersection line 4 an X-shaped unit, where the neighbouring planoparallel plates 11, 12, 13, 14 are at an angle of 90°±20° to each other and the light reflecting surfaces are optical layers that partly reflect and partly transmit the natural or polarised light.

6. Optical beam-splitter unit which has transparent planoparallel plates starting at a common intersection line with light reflecting surfaces that diverge towards the light beam to be split characterised by that this unit has three planoparallel plates (11', 12', 13'), each thinner than 0.4 mm, which form in the cross-section at right angles to the intersection line (4), an X-shaped unit (22), where end faces of the two planoparallel plates (11'; 13') that are shorter

that the third planoparallel plate (12') are butted up to the middle parts of the faces of the third planoparallel plate so that they form a continuation of each other on each side of the third thin plate, and in which unit (22) the angle between the longer planoparallel plate (12') and the shorter planoparallel plates (11' and 13') is individually 90°±20° with respect to each other and the planoparallel plates (11', 12', 13') are either semitransparent mirrors, or polarisers that completely transmit the light component polarised in the one direction and partly transmit and partly reflect the light component polarised in the other direction.

7. Binocular picture display unit which has an optical beam-splitter unit, and furthermore contains first focusing elements 24 and mirrors in front of the eyes 25 characterised by that its optical beam-splitter unit is as the optical beam-splitter unit in any of claims 1 to 6 and two first focusing elements 24 are positioned at two opposite sides of the optical beam splitter unit as seen from the direction of the light beam arriving to the semitransparent reflective surfaces of the optical beam-splitter unit – i.e. from the receiving direction 5 – and the common optical axis 23 of the first focusing elements 24 is at right angles to the receiving direction 5, and on both sides, outside the first focusing elements 24, mirrors 25 are positioned in front of the eyes, and the reflective surfaces of these mirrors form an angle 45°±15° (δ) with the above mentioned optical axis 23, and the intersection line of the planes of the reflective surfaces of these mirrors 25 is parallel or perpendicular to the intersection line of the mirror-crossing intersection line 4 of the semitransparent reflective surfaces of the optical beam-splitter 22.

8.Device as in claim 7 characterised by that the optical beam-splitter unit 22, the first focusing elements 24 and the mirrors in front of the eyes 25 are encased with a cover 28, which contains a light-admitting opening 28a, 28b in front of the mirrors 25 that are in front of the eyes and at the receiving side of the optical beam-splitter unit 22.

9. Picture display unit as in claim 7 characterised by that the optical beam-splitter unit 22 and the first focusing elements 24 are fitted in a housing 30, which has a light admitting opening at the first focusing elements 24, and which is covered by a cover-plate 43, and the mirrors in front of the eyes 25 are attached to a first slider 37 and a second slider 38 the stems of which protruding into the housing 30 are toothed racks 40 which are parallel to each other, and in between them there is a cogwheel 39 that connects them and can move them in opposite directions.

10. Picture display unit as in any of claims 7 to 9 characterised by that it contains an object source.

11. Picture display unit as in claim 10, characterised by that the object source is the screen 49a of a microdisplay 49.

12. Picture display unit as in claim 11 characterised by that the plane of the microdisplay 49 screen 49a is parallel to the plane determined by the mirror-crossing intersection line 4 and by the optical axis 23, and it is placed at the receiving side of the optical beam-splitter unit 22.

13. Picture display unit as in claim 12 characterised by that it contains at least one light source lighting the screen 49a of the microdisplay 49, such as an LED 95.

14. The display device according to claims 12 or 13 characterised by that in front of the screen 49a of microdisplay 49 there is a reflecting or focusing element 94 placed on the other side of the element 22 which projects the light-beam of the light source, favourably an LED 95, onto the screen 49a.

15. Picture display unit as in claim 12 characterised by that it contains a light source illuminating through the microdisplay unit 49 from behind, and it is placed between the microdisplay unit 49 and the device casing 51.

16. Picture display unit as in any of claims 12 to 15 characterised by that on the two sides of the optical beam-splitter unit 22, in the light path, there are liquid crystal shutters 69 at right angles to the axes of the first focusing elements 24.

17. Picture display unit as in any of claims 12 to 16 characterised by that it contains two clip plates 60 that are made in as one unit with the device casing 51.

18. Picture display unit as in any of claims 12 to 16 characterised by that on the side of the device casing 51 close to the head of the user of the device there are two

hook rails 53 made in one piece with the device casing 51, and the generators of which are parallel to each other.

19. Picture display unit as in claim 18 characterised by that the device contains a clip adapter 58 fitted in between the hook rails 53.

20. Picture display unit as in claim 19, characterised by that the clip adapter 58 consists of a bent plate 59 following the curve of the dent 52 in the device casing 51, two clip plates 60 and wing plates 61 the span width of which is equal to the distance between the hook rails 53.

21. Picture display unit as in any of claims 18 to 20 characterised by that it contains a bearing frame 70 which consists of two spectacle side-arms 71, a bridge 73 connecting them and attached to them with joint structures 72, nose supporting arms 74 attached to the bridge 73 and a device fixing unit.

22. Picture display unit as in claim 21 characterised by that the bridge 73 is a narrow plate the upper surface of which coincides or is parallel to the plane laid on the spectacle side-arms 71, and its maximum thickness s is 1.7 mm.

23. Picture display unit as in claims 21 or 22 characterised by that the nose support consists of two nose supporting arms 74 which point downwards, are parallel to each other and are situated at the same distance from the

centre of bridge 73, and of two nose supporting pads 75 attached to the end of these, and the device fixing unit consists of two U-profile fixing rails 76 which point downwards, are closed at the bottom, are parallel to each other and are situated at the same distance from the centre of the bridge 73.

24. Picture display unit as in any of claims 7 to 23 characterised by that it contains at least one microdisplay drive circuit 77, and/or radio frequency receiver-transmitter circuit 78, and/or a power source 79 and/or microprocessor 80.

25. Picture display unit as in any of claims 7 to 24 characterised by that above one end of the casing 51 there is a CCD picture recording chip 81 sensitive to the infrared range, and above its other end a front lens 82 is placed in a way that the third optical axis 83 of the front lens 82 is at right angles to the detecting surface 84 of the CCD picture recording chip 81. Above the eye mirror 25 in front of the right eye 27 a reflecting element 85 reflective in the infrared range, transparent in the visible light wavelength range is placed in the light path between the right eye 27 and the detecting surface 84.

26. Picture display unit as in claim 25 characterised by that above the front lens 82 there is an infraLED 89, and its light is guided towards the reflecting element 85.

27. Picture display unit as in any of claims 7 to 24 characterised by that above the dent 52 in the device casing

51 created for the nose, on top of the device casing 51 there is a picture recording CCD chip 90 with a detecting surface 93 in a plane parallel to the plane determined by the optical axis 23 of the first focusing elements 24 and the mirror-crossing intersection line 4, and in front of it, above the microdisplay unit 49 there is a second front lens 91 with a fourth optical axis 92 at right angles to the detecting surface 93.

28. Binocular display unit which contains eye mirrors 25a, a microdisplay 49b placed between the eye mirrors 25a, a beam-splitting unit 22a, focussing elements 24a, a display housing 56a and bridge of the nose clip characterised by that it contains a flexible retaining loop 105 that is longer than the diameter of the head of the wearer at nose level.

29. Binocular display device according to claim 28 characterised by that the retaining loop 105 is formed in part of wholly as electric cable.

30. Binocular display device according to claim 29 characterised by that the retaining loop 105 contains two earphones 106.

31. Binocular display device according to claim 30 characterised by that the display housing 56a contains a microphone 108.

32. Binocular display device according to any of claims 29-31 characterised by that the retaining loop 105 contains a control unit 107.

33. Binocular display device according to claim 32 characterised by that either the control unit 107 or the display housing 56a contains any of the following: the microdisplay drive electronics, a radio frequency transceiver circuit, a digital television receiving circuit, a microprocessor and a power source.

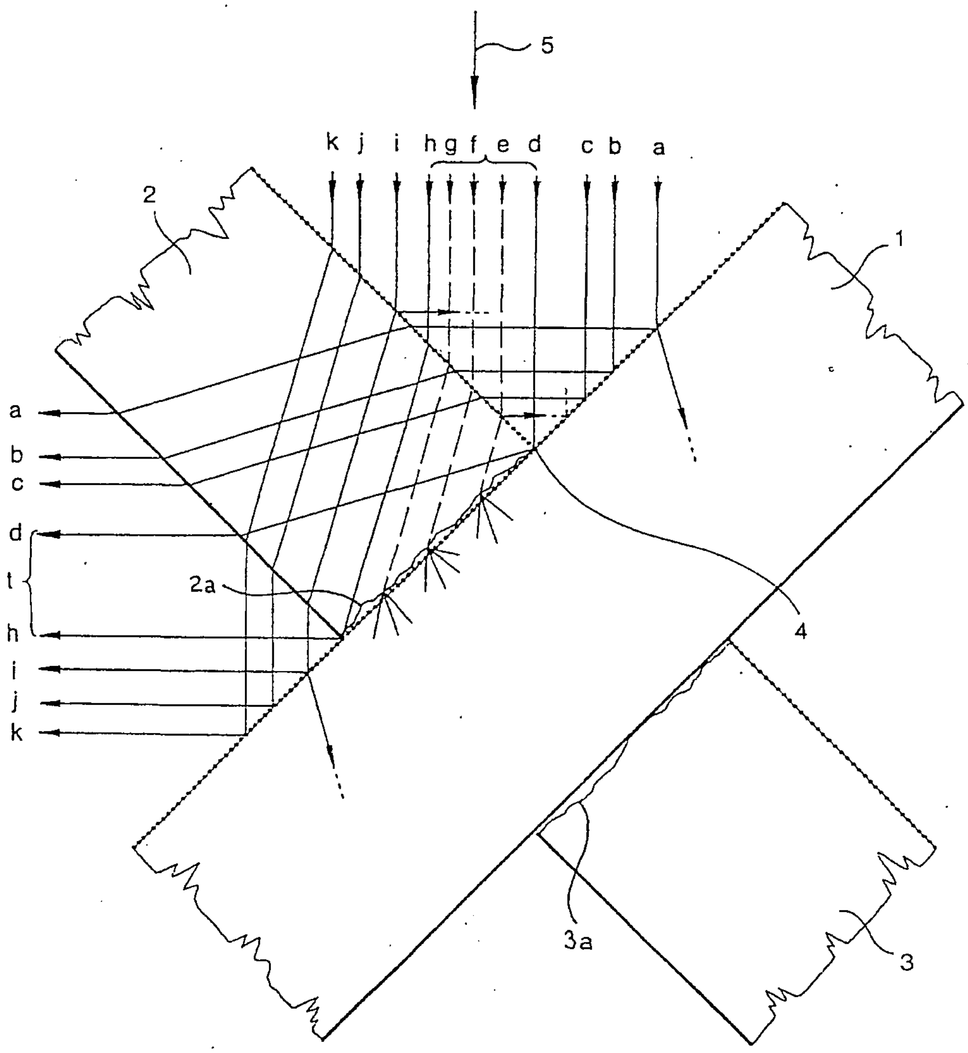


Fig. 1.

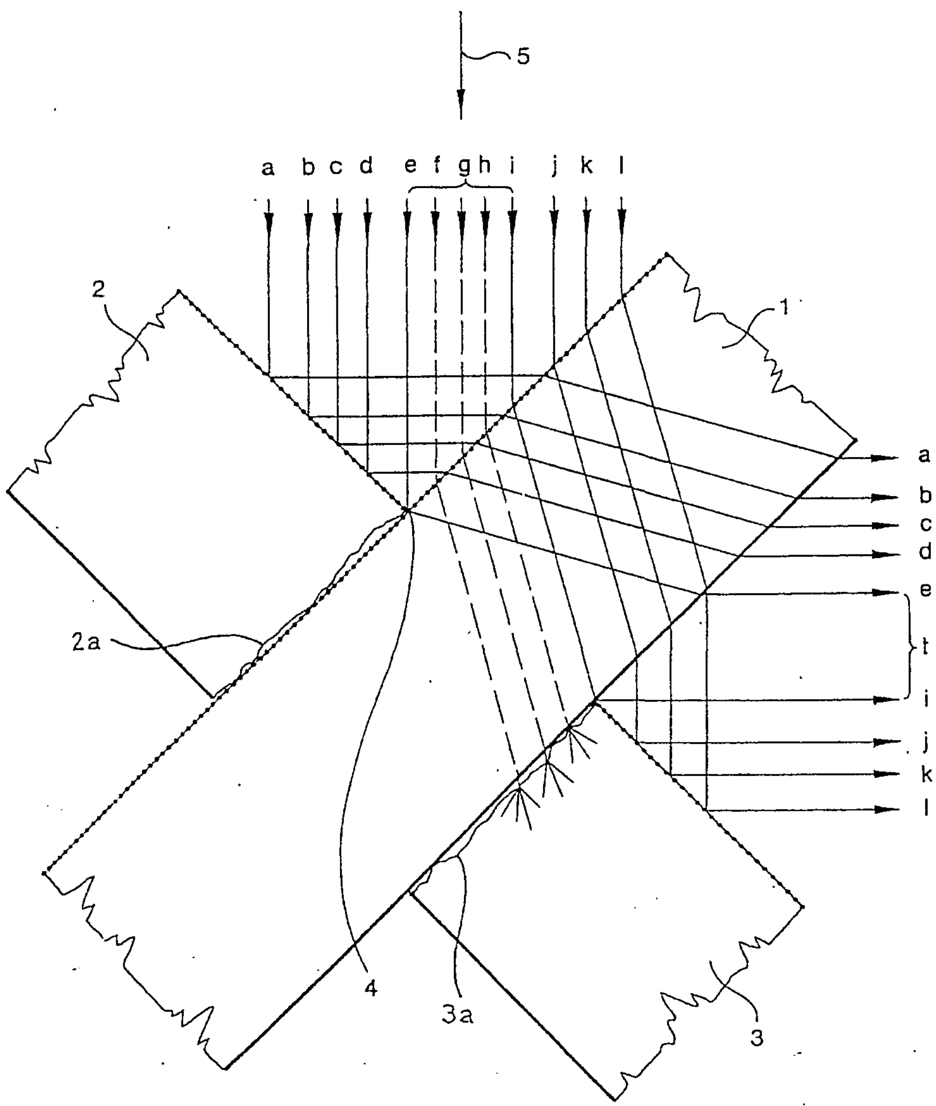


Fig. 2.

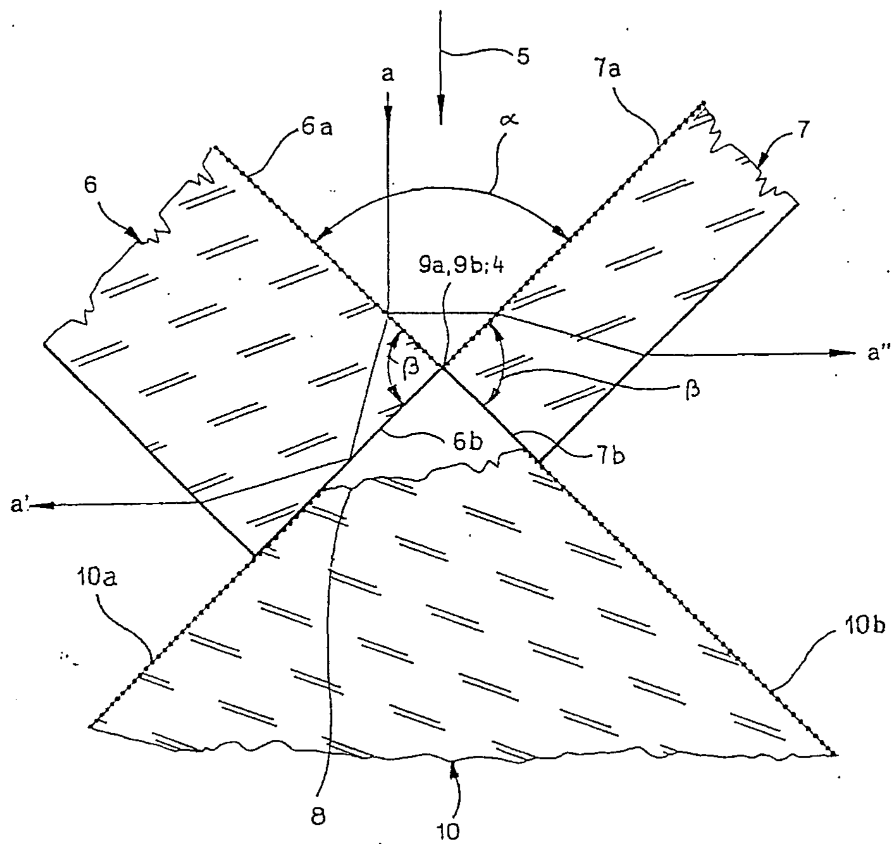
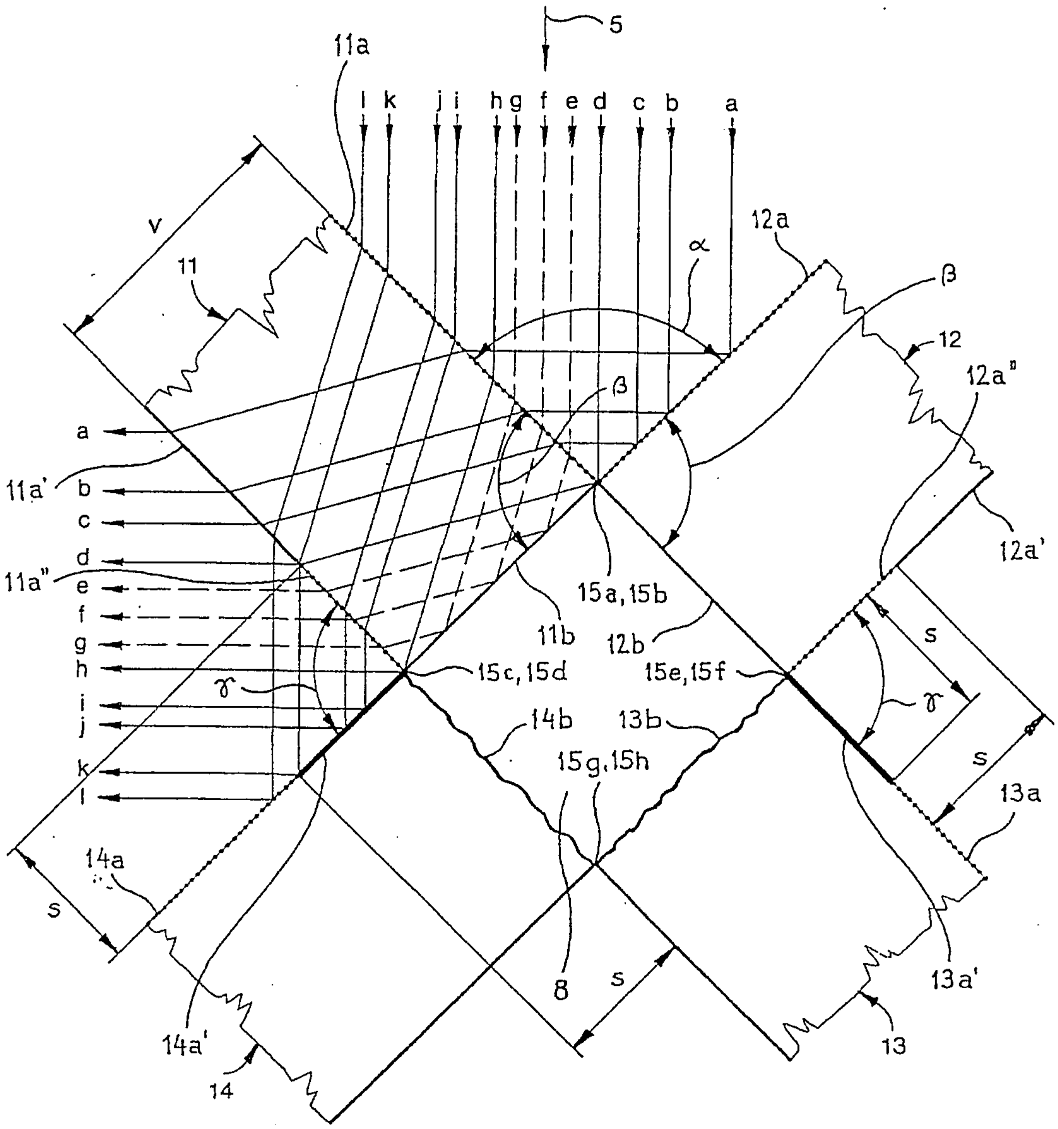


Fig. 3.


5
11a
l k j i h g f e d c b a
v
11
α
12a
β
12
12a"
β
a
11a'
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c
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11a"
e
f
g
h
i
j
k
l
12a'
15a, 15b
11b
12b
s
γ
15c, 15d
15e, 15f
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15g, 15h
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13a'
14a'
13
14

Fig. 4.

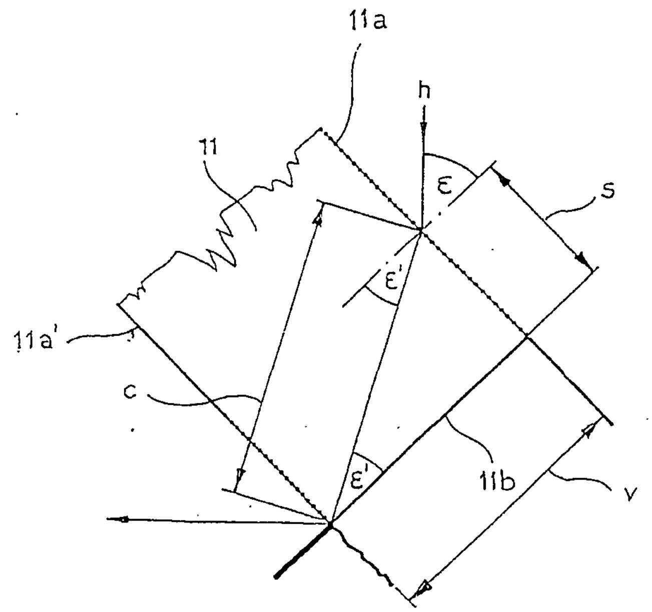
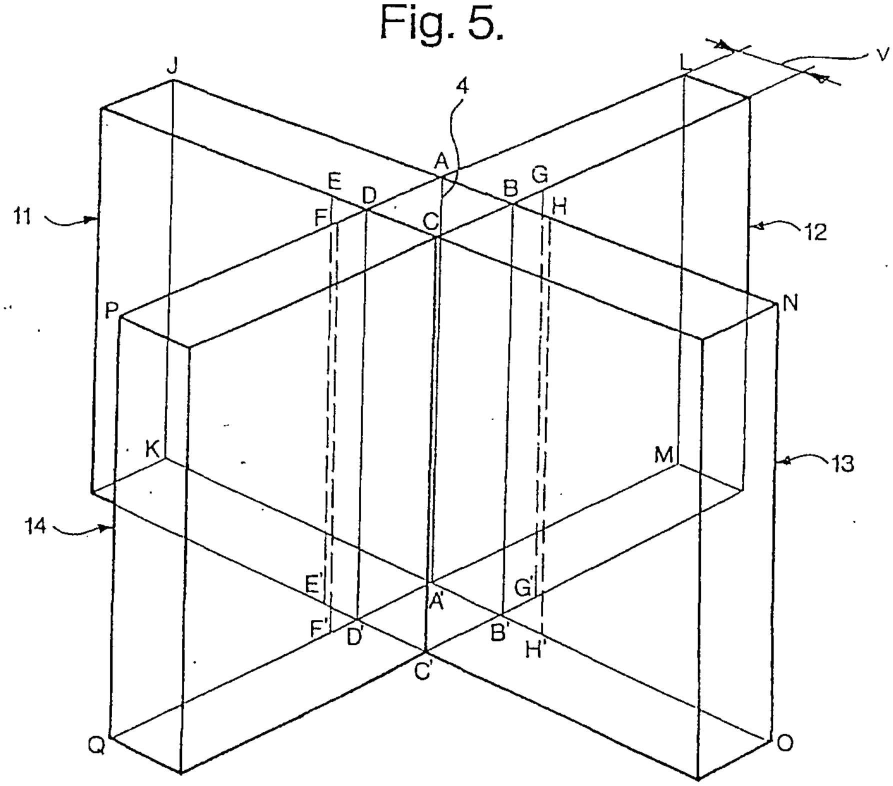

11a
h
11
ε
s
ε'
11a'
c
ε'
11b
v

Fig. 5.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B'
H'
C'
Q
O

Fig. 6.

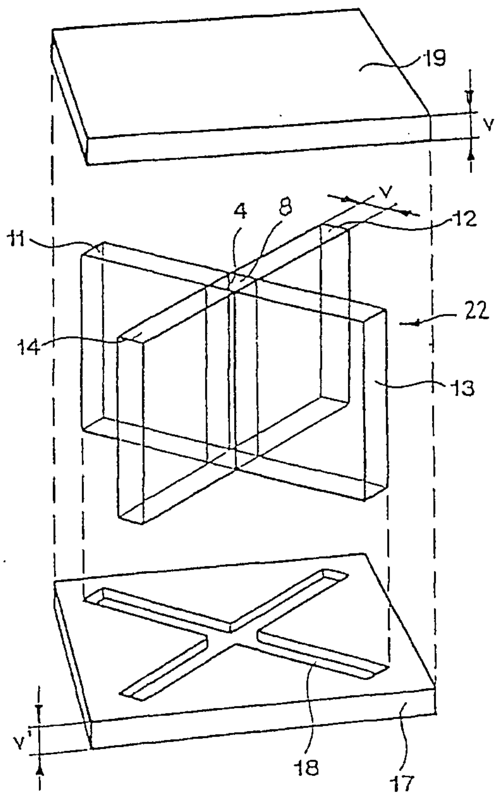
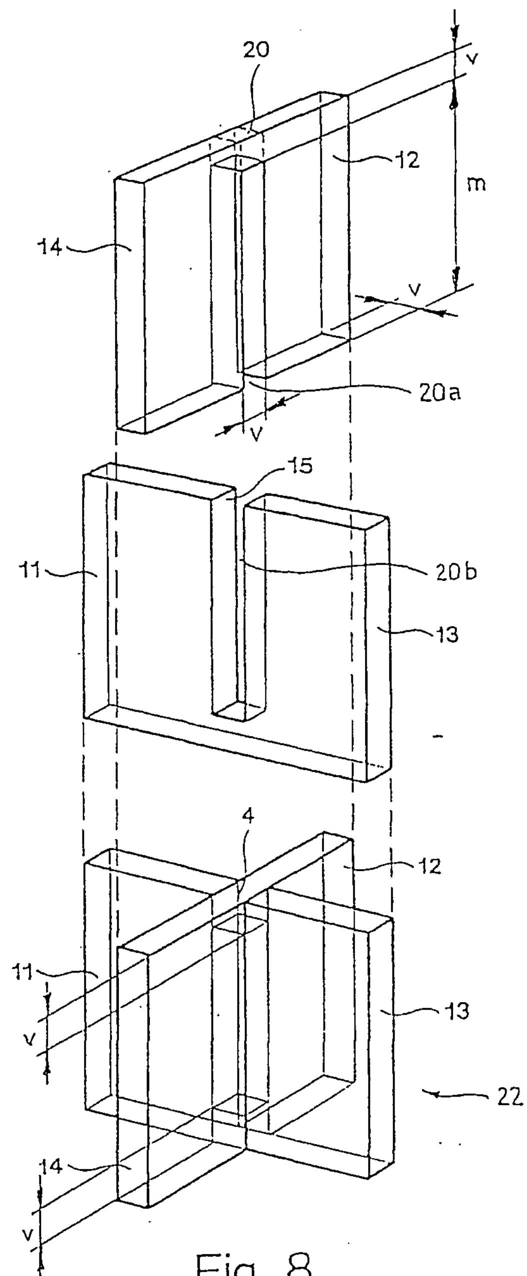


Fig. 7.



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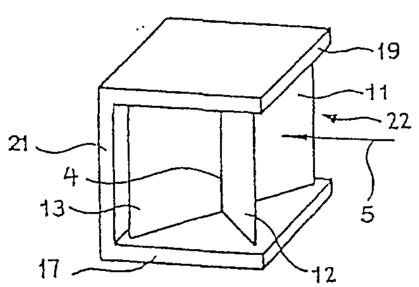
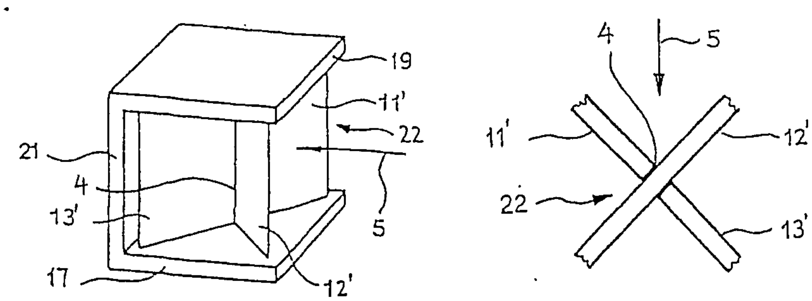


Fig. 9a.



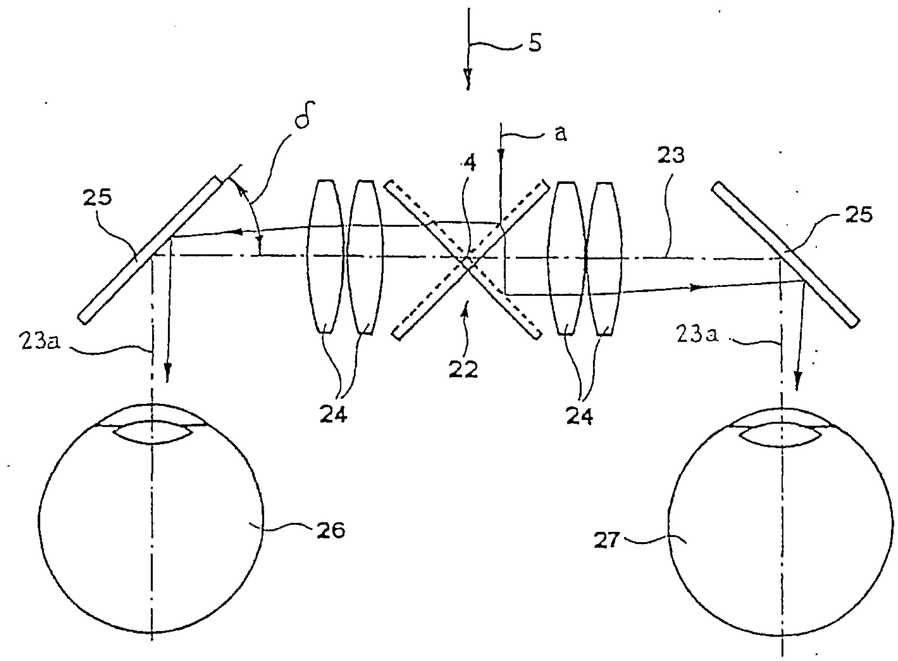


Fig. 10.

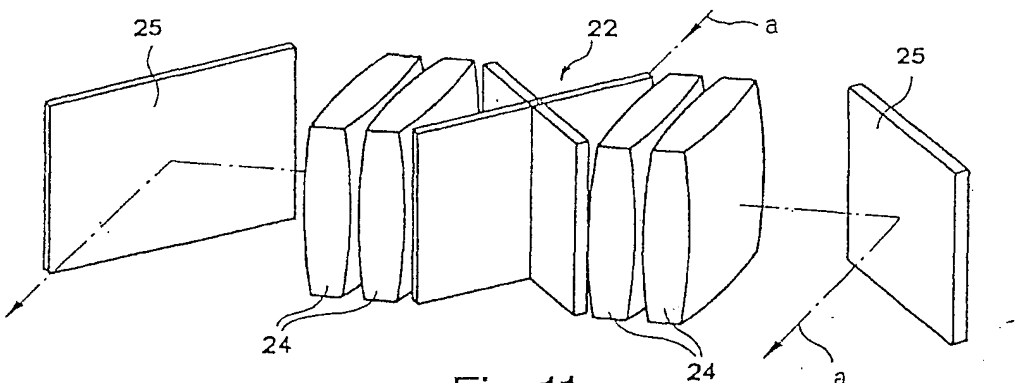


Fig. 11.

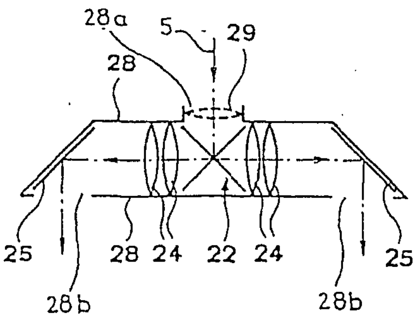


Fig. 12.

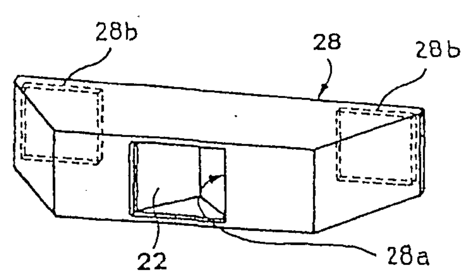


Fig. 13.

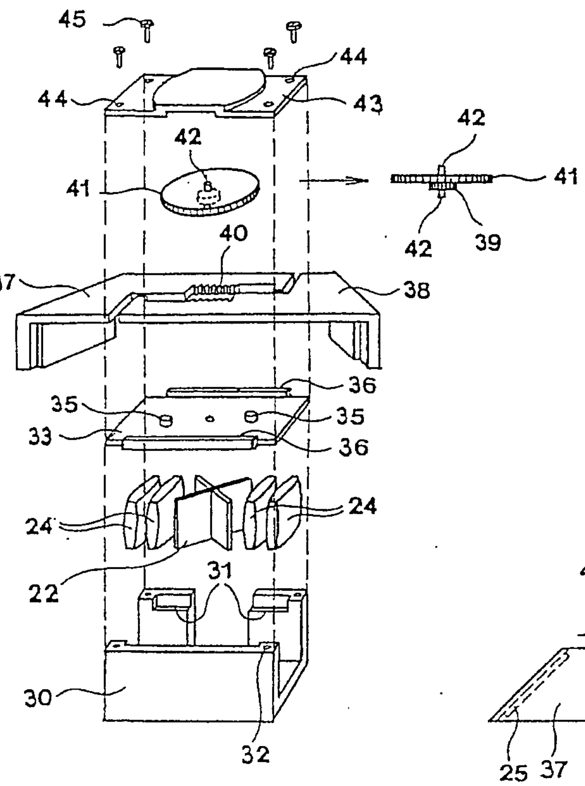


Fig. 14.

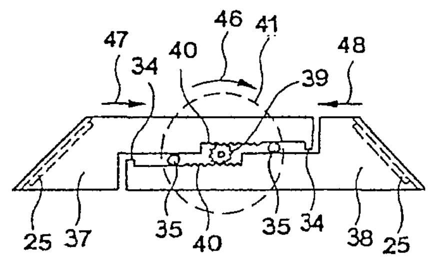


Fig. 15.

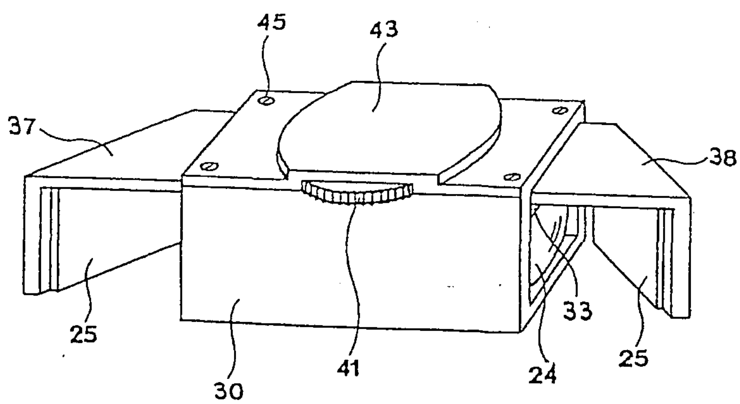


Fig. 16.

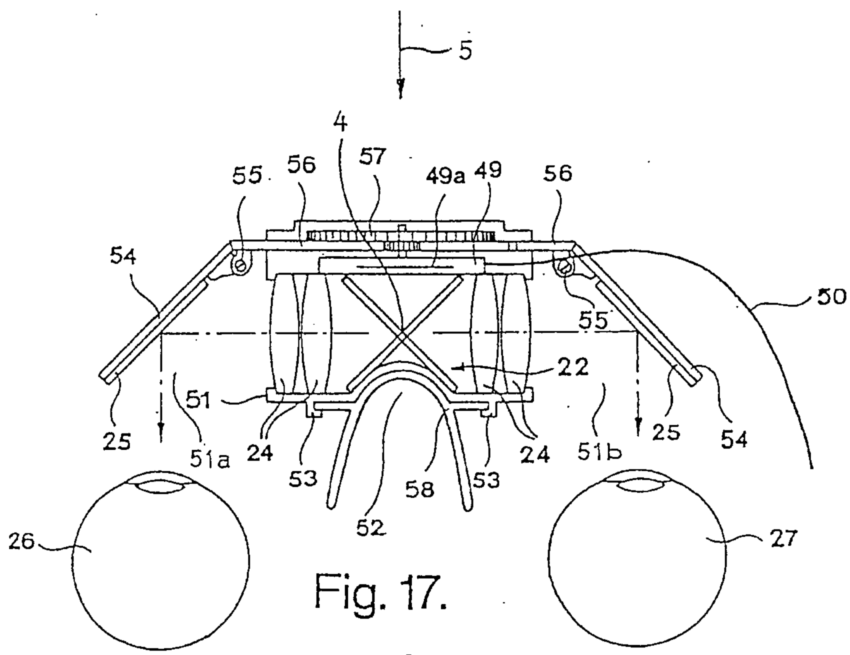


Fig. 17.

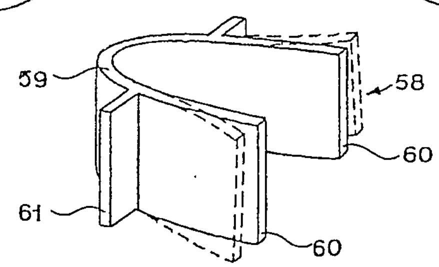
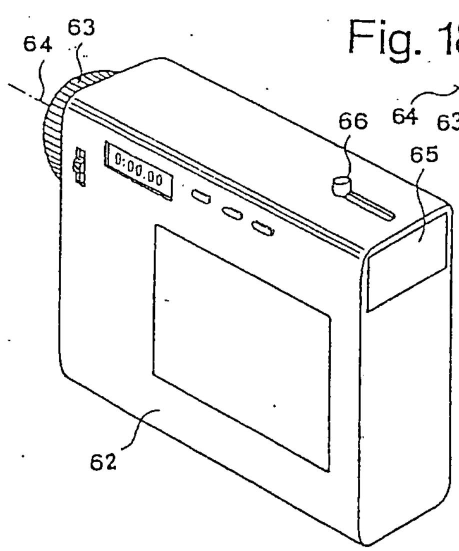


Fig. 18.



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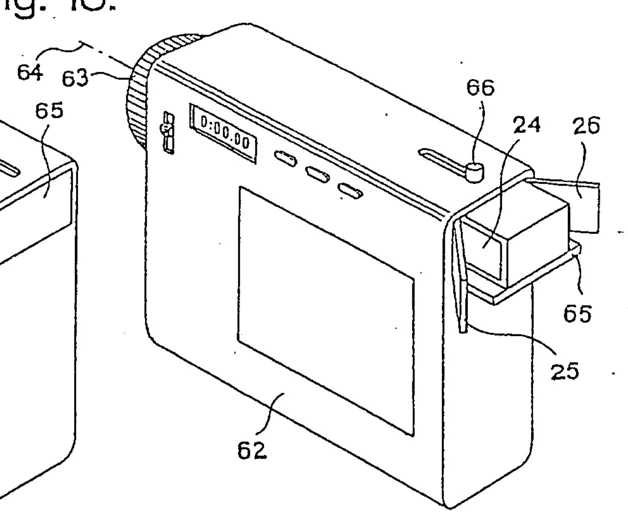


Fig. 20.

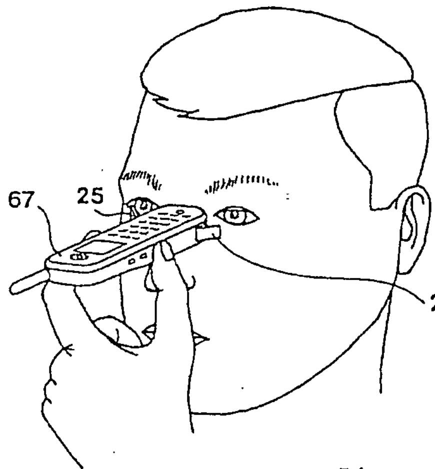


Fig. 21.

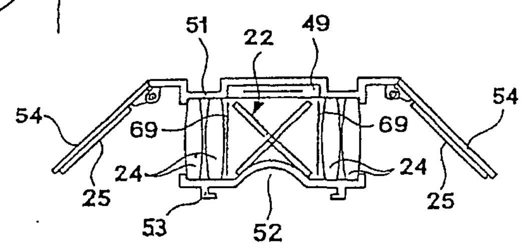


Fig. 22.

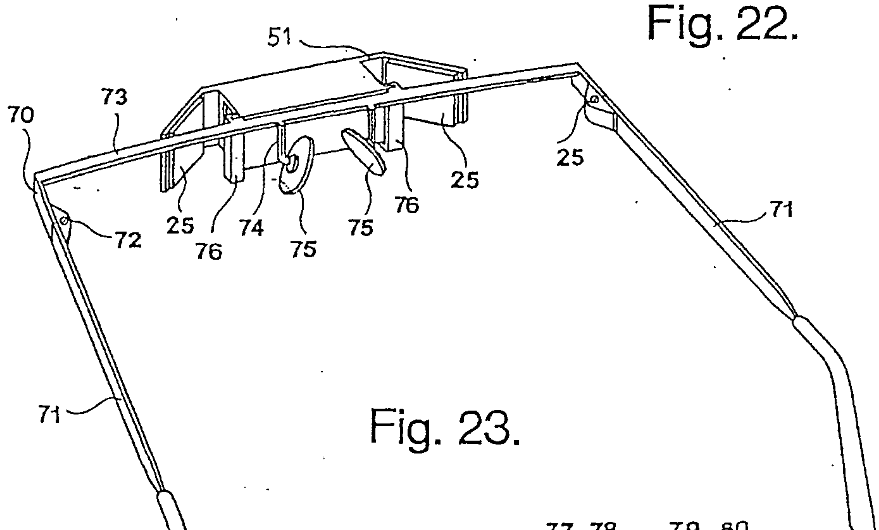


Fig. 23.

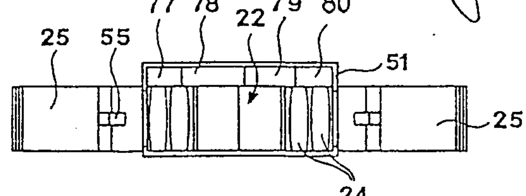


Fig. 24.

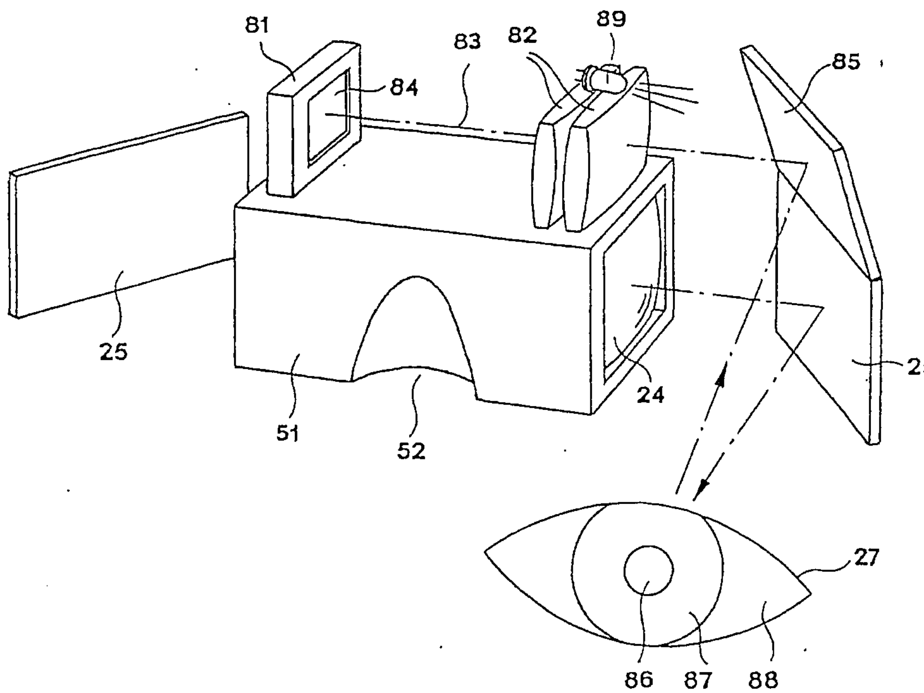


Fig. 25.

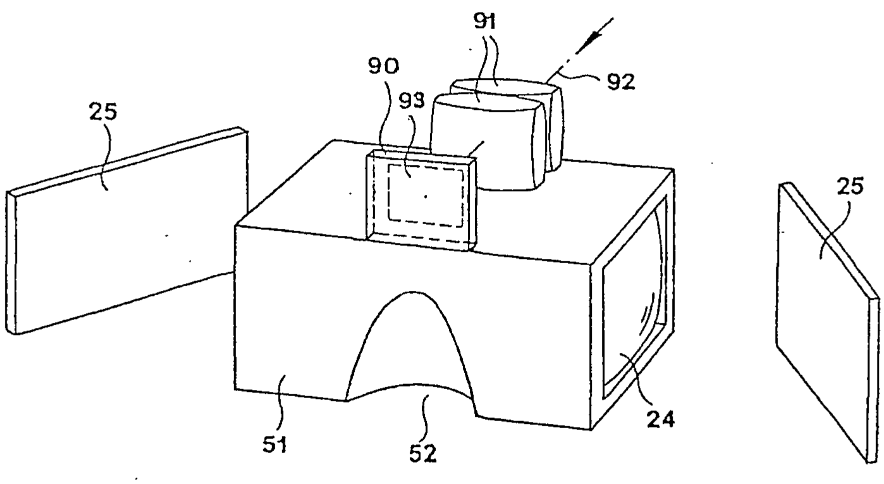


Fig. 26.

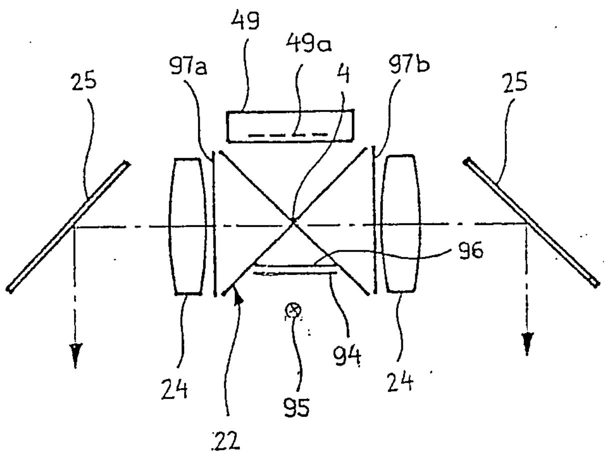


Fig. 27.

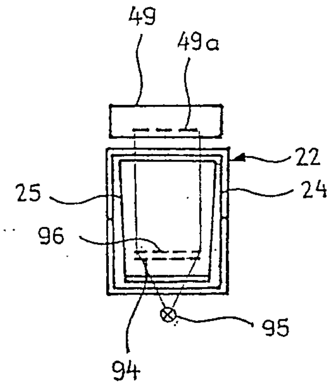
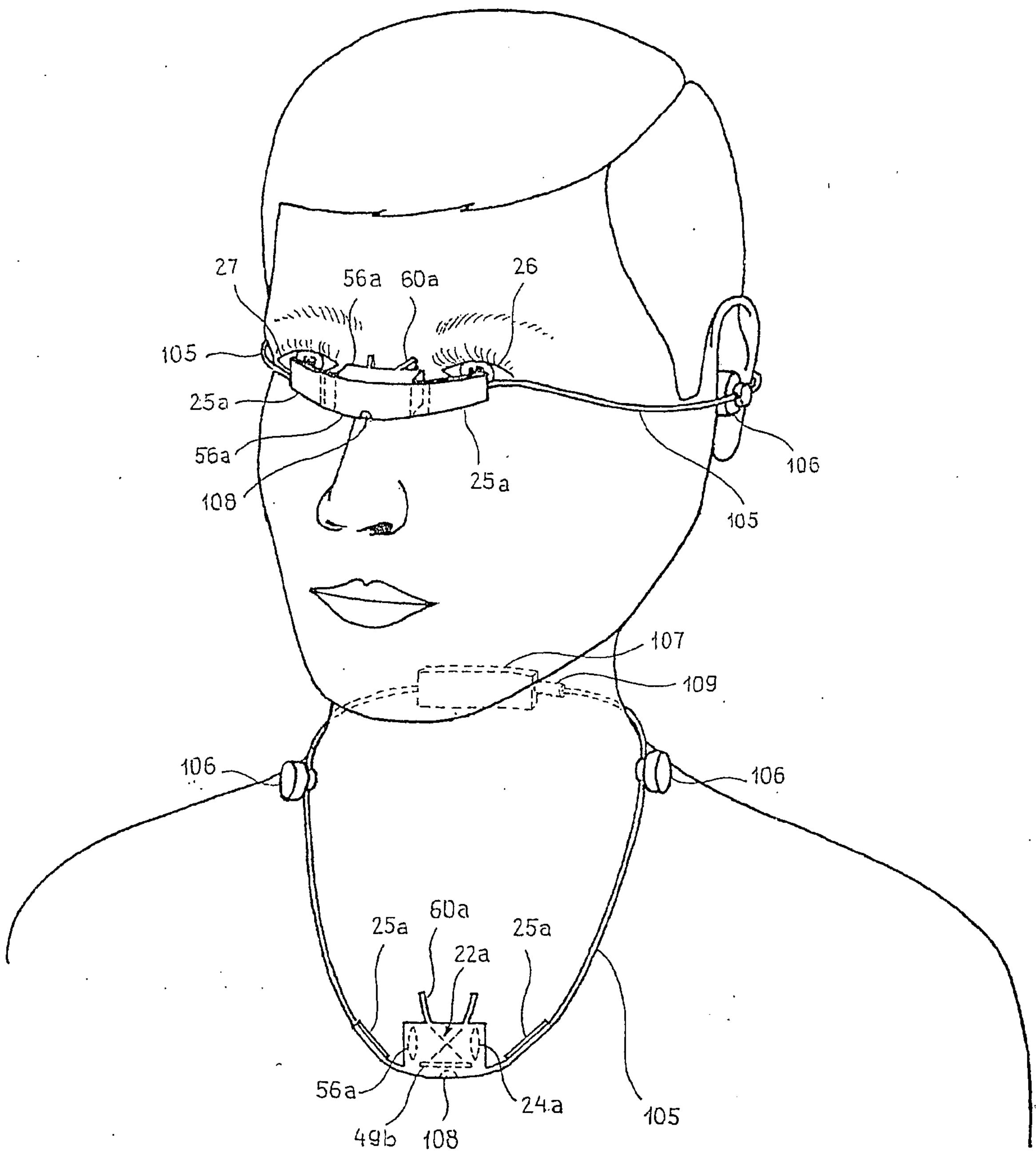


Fig. 28.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22a
56a
49b
108
24a
105

Fig. 29.

INTERNATIONAL SEARCH REPORT

Inte nal Application No
PCT/HU 00/00119

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G02B27/10 G02B27/01

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 739 955 A (MARSHALL IAN) 14 April 1998 (1998-04-14)	1,2
Y	abstract column 3, line 10 - line 19 column 5, line 1 - line 28 column 8, line 10 - line 35 figures 4,7 ---	7,10,11
X	US 2 973 683 A (ROWE L F ET AL) 7 March 1961 (1961-03-07) column 3, line 6 - line 52 column 5, line 13 - line 55; figures ---	1,2
	-/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 May 2001	27.07.01

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Mollenhauer, R

Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5 682 173 A (KEZI LASZLO ET AL) 28 October 1997 (1997-10-28) cited in the application column 2, line 16 - line 40 column 3, line 17 - line 25 column 5, line 33 - line 58 ---	7,10,11
A	WO 99 39237 A (KONINKL PHILIPS ELECTRONICS NV ;PHILIPS SVENSKA AB (SE)) 5 August 1999 (1999-08-05) page 4, line 6 - line 26; figure 2 ---	1,2
A	WO 98 10323 A (HOLMES RICHARD ;MARSHALL IAN (GB); RETINAL DISPLAY CAYMAN LTD (GB)) 12 March 1998 (1998-03-12) page 2, paragraph 4 ---	1,2
A	WO 85 04961 A (HUGHES AIRCRAFT CO) 7 November 1985 (1985-11-07) cited in the application figure 1 ---	1
P,A	US 6 101 041 A (IWAGUCHI YASUHIRO ET AL) 8 August 2000 (2000-08-08) figures	1
A	-& JP 11 084114 A (NIKON CORPORATION) 26 March 1999 (1999-03-26) figures ---	1
A	PATENT ABSTRACTS OF JAPAN vol. 1996, no. 02, 29 February 1996 (1996-02-29) -& JP 07 287185 A (SONY CORP), 31 October 1995 (1995-10-31) cited in the application abstract -----	1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/HU 00/00119

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
   because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
   because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
   because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

   1-4,7-27

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-4,7-27 (as far as dependent on claims 1-4)

   improve a beam splitting device by allowing every ray contained in a parallel beam to be reflected with the same intensity

2. Claims: 5,6,7-27 (as far as dependent on claims 5,6)

   reduce the mass of a beam splitter containing three or four plates

3. Claims: 28-33

   improve the use of a retaining loop of a portable binocular display

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
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